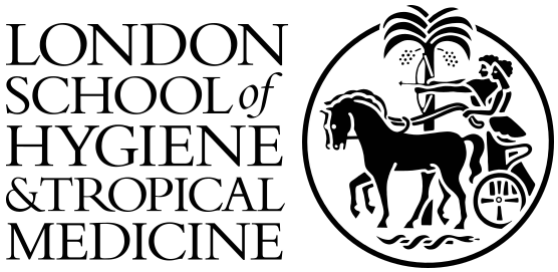

Integrating insecticide treated nets with routine antenatal care and immunization programmes: Policy, practice, and coverage

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I, Katherine Theiss-Nyland, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Signed: 

ABSTRACT

Background

Insecticide treated nets (ITNs) are the primary means of vector control for malaria prevention. As of 2015, 82 countries provided ITNs free, nationally or sub-nationally, usually via mass campaigns, for the prevention of malaria. The WHO currently recommends that ITNs be distributed through the routine facility-based channels of antenatal care (ANC) and the expanded programme on immunization (EPI), in addition to mass-distribution campaigns. This research aimed to assess routine facility-based distribution in Africa, in terms of policy, practice and coverage.

Methods

Both qualitative and quantitative methods were used to assess facility-based ITN distribution. The quantitative methods used included an analysis of the availability of ITNs for routine distribution in Africa via ANC and EPI, using nationally reported ITN data provided to the WHO. A DHS analysis was also conducted to analyse ITN ownership and use, as well as coverage and equity for integrated and non-integrated country ITN programmes. A Qualitative study in four sub-Saharan African countries evaluated the operational challenges of facility-based ITN distribution. The qualitative study also gave rise to a comparison of ANC and EPI as ITN integration platforms.

Results

There were more ITNs available for distribution via ANC than EPI. ANC programmes had stronger integrated practices for management, monitoring and evaluation, compared to EPI. Stock-outs and stock-out response systems are more problematic for ITNs distributed through both ANC and EPI than for other routine health service commodities, such as vaccines and HIV drugs. Countries with integrated ITN services through both ANC and EPI have higher household ITN ownership and use in children under-5 compared to countries with only ANC-based distribution, or without any ITN integration. Integration is correlated with improved coverage of ITN, and improved equity scores for EPI, compared to countries without integration.

Conclusion

ITN distribution through ANC and EPI is not yet universally implemented despite WHO recommendations. While integration via ANC is easier due to the ANC systems already in place, EPI may have more to gain from integration in terms of both coverage and equity for children under five. To better measure the impact of integrated services, routine monitoring of ITN distribution is necessary.

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

AIDS – Acquired immune deficiency syndrome

ANC – Antenatal care

BCG - Bacille de Calmette et Guérin vaccine (vaccine against tuberculosis)

DALY – Disability Adjusted Life-Year

DDT- Dichloro-diphenyl-trichloroethane

DFID – UK Department for International Development

DHS – Demographic and Health Surveys

DTP – Diphtheria-Tetanus-Pertussis Vaccine

DTP1 – The first dose of the DTP vaccine

DTP3 – The third dose of the DTP vaccine

DRC – Democratic Republic of Congo

EID – Early Infant Diagnostics (for HIV)

EPI – The Expanded Programme on Immunization

GAVI – Global Alliance for Vaccines and Immunizations

GIVS – Global Immunization Vision and Strategy

GMEP – Global Malaria Eradication Programme

GVAP – Global Vaccine Action Plan

HBV – Hepatitis B vaccine

Hib – Haemophilus influenzae type-b vaccine

HIV – Human Immunodeficiency Virus

IMCI – Integrated Management of Childhood Illnesses

IPTc – Intermittent Preventive Treatment of Malaria in Children

IPTi – Intermittent Preventive Treatment of Malaria in Infancy

IPTp – Intermittent Preventive Treatment of Malaria in Pregnancy

IPTp-SP – Intermittent Preventive Treatment of Malaria in Pregnancy with Sulfadoxine-pyrimethamine

IRB – Institutional Review Board

IRS – Indoor residual spraying

ITN – Insecticide-treated net

JHU – Johns Hopkins University

LiST – Lives Saved Tool

Log Frame – Logical Framework Approach

LLIN – Long-lasting insecticide-treated net

LSHTM – London School of Hygiene and Tropical Medicine

MCV – Measles Containing Vaccine

MDG – Millennium Development Goals

MEASURE – Monitoring and evaluation to assess and use results

MERG – Monitoring and Evaluation Reference Group

MiP – Malaria in pregnancy

MIS – Malaria Indicator Survey

NetCalc – Excel based mosquito net modelling tool

NetWorks - a USAID-funded project to prevent malaria by increasing access to LLINs

NMCP – National Malaria Control Programme

OPV – Oral polio vaccine

ORS – Oral Rehydration Salts

Penta – Pentavalent vaccine

PCV – Pneumococcal Conjugate Vaccine

PMI – the Presidents Malaria Initiative

RAP – Rapid Assessment Process

RBM – Roll Back Malaria

RCT – Randomized control trial

SMC – Seasonal Malaria Chemoprevention

SP - Sulfadoxine-pyrimethamine

Stata – Data analysis and statistical software

TT – Tetanus toxoid vaccine

UN – United Nations

UNICEF – United Nations Children's Fund

UNFPA – United Nationals Population Fund

USAID – United States Agency for International Development

UTN – Untreated nets (for protection against mosquitoes and other insects)

VCWG – Vector Control Working Group

WER – World Epidemiological Review

WFS – World Fertility Survey

WHA – World Health Assembly

WHO – World Health Organization

WMEP – World Malaria Eradication Programme

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

Malaria is a vector-borne infectious disease transmitted by *Anopheles* mosquitoes. In 2015, there were approximately 214 million cases of malaria worldwide, resulting in an estimated 450,000 deaths.[1] The majority of malaria morbidity and mortality is concentrated in sub-Saharan Africa. Prevention and treatment of malaria are major public health concerns, with approximately 2.9 billion US dollars spent in 2015 on efforts to reduce morbidity and mortality.[2,3]

Among many interventions designed for the control of malaria, routine facility-based distribution of insecticide treated nets (ITN) is a collection of distribution strategies aimed at providing mosquito bed-nets to pregnant women during antenatal care visits, and to infants during immunization visits, to prevent malaria during pregnancy and infancy. The WHO recommends these distribution channels for all malaria endemic countries, in addition to mass distribution campaigns. Despite these recommendations, there has been limited research on the implementation and effectiveness of these distribution channels, in terms of the coverage achieved, most of which was conducted before free ITN distribution became common practice.

This chapter describes the history and current recommendations of each of the three programmes involved in the routine facility-based distribution of ITNs: malaria prevention, antenatal care (ANC) and the expanded programme on immunization (EPI). Each of these programmes developed independently as the result of historical pressures, scientific discoveries, and global health interests. The integration of ITNs into ANC and EPI services has evolved over the last few decades, and is described through a review of the literature on the topic. Understanding the origins and structures of these programmes, as well as the history of integration, is important for identifying and implementing best practices in the future.

1.1. Malaria prevention and ITNs

Descriptions of malaria-like diseases are found throughout history, as far back as ancient Chinese medical writings from 2000 BCE, to the discussion of the illnesses of prominent Europeans through the 17th century.[4,5] From 1880 to 1900, scientists made great strides in discovering the parasites in blood samples which cause malaria infections, identifying the mosquito vector as the mode of malaria transmission, and describing the malaria life-cycle responsible for morbidity and mortality in humans.[4,6]

In the first few decades of the 20th century, malaria control consisted of vector control strategies, case management, and treatment of individuals with quinine. The 1930s and 1940s saw three significant advancements in the history of malaria control: the identification of chloroquine - a new effective antimalarial drug, the development of indoor residual spraying (IRS), and the discovery of the pesticide dichloro-diphenyl-trichloroethane (DDT).[7] IRS is a system of spraying insecticide on the inside of homes in an effort to kill mosquitoes when they rest on walls to digest a blood meal.[8] IRS began in the early 1930s as a malaria control strategy, using pyrethrum extracts, but due to the weekly reapplication required to maintain effectiveness, the intervention had limited use and was only available in urban areas.[7] DDT, by comparison, only required reapplication every six months to one year, making mass treatment of rural homes possible.[7] Following the success of numerous IRS field trials using DDT in the 1940s and 1950s, DDT was adopted as a national and regional malaria control strategy in many countries. The impressive success of DDT at halting plasmodium transmission and malaria infections led to the development of a global malaria eradication strategy.[6,7]

In 1955, at the World Health Assembly (WHA), the United Nations (UN) approved the proposal for a Global Malaria Eradication Programme (GMEP) which would be led by the World Health Organization (WHO). By this point mosquito resistance to the insecticide DDT had begun, prompting world leaders in health to emphasize the importance of a coordinated global effort towards eradication while DDT was still effective.[6,7] Focusing solely on IRS with DDT, the GMEP saw great successes in the overall reduction of the geographical distribution of malaria globally, and the elimination of malaria in the United States, Europe, and Australia.[7] However, the programme had no significant success in sub-Saharan Africa, where 80% of malaria infections occur.[6] By the mid-1960s the emergence of drug resistance, widespread DDT resistance, as well as the technical challenges of implementation in Africa, led to the collapse of GMEP.[4] In 1969 the GMEP was declared a failure and abandoned.[6]

The "post-eradication era" from 1969 to 1991 switched efforts towards malaria control, and focused on the identification and development innovative technologies.[6] During this period, new malaria drugs were identified, diversified vector control strategies were investigated, and the search for a malaria vaccine began.[6] These new technical developments renewed the global interest and commitment to malaria control moving forward.[6]

The WHO malaria prevention strategy currently consists of two main categories of interventions: preventive therapies and vector control.[1] Preventive therapies are courses of malaria treatment, provided systematically to target groups to kill any parasite within the body

at the time of treatment, and prevent new infections through the residual effects of the treatment. Preventative therapies for malaria currently in use include intermittent preventive treatment for pregnancy (IPTp) and for infants (IPTi), as well as Seasonal Malaria Chemoprevention (SMC) for children. IPTp programmes provide a course of anti-malarials, (currently sulfadoxine-pyrimethamine (SP) is recommended monthly during the second and third trimester of pregnancy), as part of antenatal care to prevent malaria infection in mothers and transmission to babies in utero.[9–11] IPTi and SMC are both programmes that target children, but are used in different transmission settings. IPTi is recommended for high intensity non-seasonal transmission settings, and often uses routine immunization services as the entry point for service delivery.[12–14] SMC, by comparison, is approved for implementation in highly seasonal transmission settings and provides treatment to children two to four times during the high transmission season, either at community distribution points, or at health facilities.[15]

Vector control primarily consists of IRS (discussed above) and insecticide-treated bednets (ITN). Other vector control strategies exist, including larvicide and biological controls to kill early stage mosquito development, elimination of breeding habitats, but have limited uptake and application gloabally.[16] IRS is a more commonly used vector control strategy for malaria, with more than ten different approved insecticides now available for IRS use.[17] ITNs are the most widespread means of malaria prevention globally, with 82 countries distributing nets free of charge.[8,16] ITNs provide a physical barrier between people and mosquitoes to prevent infectious bites, as well as an insecticide-treated surface, which can repel and kill mosquitoes that come into contact with it.

In many cultures, traditional “mosquito nets” have been used as a physical barrier between people and both nuisance and disease carrying insects, long before they were identified as a malaria control strategy. In the 1980s studies first measured the effect of bed-nets treated with pyrethroid insecticides (insecticide-treated nets: ITN) in reducing malaria.[18] This new-found vector control strategy, in combination with the discovery of artemisinin-based combined therapies (ACT) as malaria treatment, revitalized the malaria prevention efforts. By the mid-1990s, the use of ITNs became a global recommendation and national policy for many malaria control programmes. In the late 1990s and early 2000s more trials described the role ITNs play in reducing disease, yet coverage of ITNs remained low in most places.[18] A Cochrane systematic review and meta-analysis in 2004 evaluated 22 trials of bednets from Africa, Latin

America and Asia, and found an overall reduction in clinical episodes of malaria of 50%, and an 18% reduction in child mortality, attributable to ITNs.[19]

Distribution of ITNs throughout the late 1980s and 1990s focused on social marketing of subsidized nets in an effort towards both sustainable programming and equitable coverage. However, by the year 2001, only 3% of homes in Africa had at least one ITN, as reported by 34 countries to the WHO, while 5 times that number of households had locally produced non-treated nets, highlighting the poor uptake of socially marketed ITNs.[8,18]

In 2002, Roll Back Malaria released the first strategic framework on ITNs, which identified pregnant women as an important vulnerable group for targeted ITN distribution.[20] An update to this strategic framework, released in 2005, went further to identify ANC and EPI as possible distribution channels for ITNs.[21] In 2004, WHO AFRO developed a strategic framework for malaria in pregnancy, which also identified ANC as a possible distribution channel to reach this target group.[22]

In 2004, the first nationwide ITN distribution through an integrated vaccination campaign took place in Togo. The campaign successfully achieved >90% coverage of both measles-vaccine in eligible children, and ITN ownership for eligible households, measured as at least one net per house.[23,24] This national programme took place just after similar sub-national programmes in Ghana and Zambia which achieved 94.4% and 81.1% household ITN ownership in target populations, respectively.[25,26] These programmes found integrated campaigns to be both cost-effective and efficient for the rapid scale-up of ITNs in a way that social marketing had not been. In 2007, the WHO made a new recommendation that ITNs be distributed free or highly subsidized universally to all individuals, not just to targeted groups such as women and children.[27] In the same year a new type of ITN became available: long-lasting insecticidal nets (LLINs)[a], removing the need for repeated net treatment with insecticides. This advancement improved the cost associated with ITNs, by removing the need for retreatment campaigns

[a] The term long-lasting insecticidal net (LLIN) describes a specific type of insecticide treated net (ITN). Since 2010, all ITNs approved by WHO for purchase and distribution using donor funding, have been LLINs. In each results chapter of this PhD either the term "LLIN" or "ITN" is used. In chapter 4, the term LLIN is used because the WHO dataset used for the analysis specifically reported LLINs in the years included. In chapters 5 and 6, the analysis evaluated the policy and implementation currently in practice for the distribution of LLINs. Chapters 7 and 8, by comparison, used DHS data to look retrospectively at household ITN ownership. Not all countries datasets differentiated between ITNs and LLINs. Because the analysis included ITNs distributed in the past, it could not exclusively discuss LLINs, though the majority of the ITNs discussed in those chapters are likely LLINs.

which could be labour intensive. As a result, mass distribution campaigns became the dominant distribution method.[27]

Between 2008 and 2010, 295 million ITNs were distributed, largely via independent mass campaigns, throughout Africa.[28] Over 90% of ITNs distributed worldwide come from mass distribution campaigns, but many other distribution strategies have been developed and are used alongside campaigns. Currently ITN policies for bednet distribution vary by country and region, and may include free distribution, subsidized distribution, distribution to target groups, targeted campaigns, integrated distribution through ANC and/or EPI, school based distribution, and mass campaigns.

1.2. The Expanded Programme on Immunization

The Expanded Programme on Immunization[b] (EPI) was established between 1974 and 1977 by the WHO to increase global access to childhood immunizations.[29,30] Before EPI began, only approximately 15% of children worldwide had access to vaccines.[31] While wealthy countries such as the US and the UK had routine vaccination programmes in place as early as the 1940s, beginning with diphtheria vaccine (and much earlier for non-routine small pox elimination), the majority of the world's population did not have access to routine vaccination.[30] The development of EPI was due in large part to the successful smallpox eradication programme led by the WHO in the 1960s and 1970s.

When the expanded programme on immunization was developed, initial efforts focused on creating a routine health system, with the physical delivery structure and human resources necessary to provide vaccination to children.[30,32] The EPI programme established a standard vaccination schedule during infancy, to address the age specific disease burden of vaccine preventable diseases.[30] The specific format for vaccination delivery, and the list of vaccines to include, was based on information about each vaccine's effectiveness, the age at which

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[b] The term "immunization" was chosen for EPI, instead of "vaccination" with good reason. Vaccination is defined as the administration of a vaccine, which immunization is defined as vaccination which produces an immune response to confer protection against a specific disease. At the time when EPI was established, there were many vaccines on the market that had not been rigorously tested, and did not induce a sufficient immune response to protect against disease. The WHO made an explicit choice to include only the vaccines which had been rigorously tested, and resulted in immunological protection against disease.

When discussing modern, WHO approved vaccinations, these terms are often used interchangeably. In this document, I use both terms, but tend to focus on immunization in relation to the programme (EPI) and vaccination when discussing the delivery of vaccines.

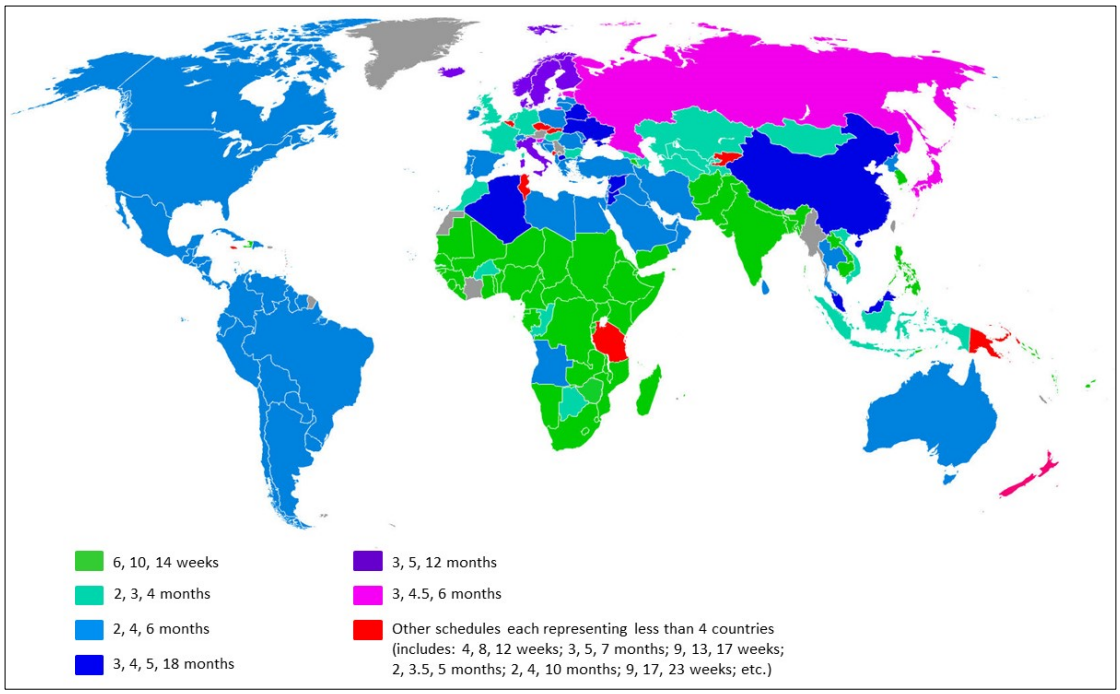
children were at risk of infection, age-specific immune response, disease burden, and the presence (or absence) of maternal antibodies that would render the vaccine less effective, and programmatic feasability.[32]

The original EPI schedule included six antigens (as four vaccines) given within the first year of life: BCG at birth; diphtheria, tetanus, pertussis (DTP); and oral polio vaccine (OPV) at 6, 10, and 14 weeks of age; and measles vaccine at 9 months. [32] The programme has become a cornerstone of public health services, and routine immunization now reaches more than 4 out of 5 of the world's children.[31,33]

The list of recommended vaccines has grown since the inception of EPI, and currently includes both regionally and internationally recommended vaccines such as Yellow Fever, Hepatitis B vaccine (HepB), Haemophilus influenza B vaccine (Hib), pneumococcal conjugate vaccine (PCV), and Rotavirus vaccine. In 2000 the GAVI Alliance began supporting low- and middle-income countries in accessing new and underused vaccines, contributing to the prevention of more than 5.5 million childhood deaths.[34]

Since the inception of EPI, virtually all countries in the world have established a routine vaccination programme. The timing and number of doses for each vaccine differ globally, with common regional patterns (Figure 1). The different EPI schedules mean that depending on the country children are born and raised in, they will visit health services at different ages to receive vaccinations. The timing of the vaccine schedule also has implication for the non-vaccine maternal and child health programmes interested in using the EPI schedule as an integration platform. The WHO vaccine schedule recommendations, and the subsequent schedules implemented by countries are designed with vaccine effectiveness in mind, but without considering the age specific timing requirements for other integrated programmes.[32,35] As a result, programmes wishing to use EPI as the backbone for service delivery must align with pre-existing EPI schedules, or develop an alternative implementation timeline without the benefit of the EPI visit attendance.

Figure 1: DTP and DTP-containing vaccine schedule globally



Schedule data collated from the World Health Organization EPI statistics, March 2015

1.3. Antenatal Care Programmes

The routine provision of antenatal care (ANC), as part of public health services, began as early as the 1930s in the UK and the USA.[36] The inclusion of ANC in maternity care came after the realization that while maternal mortality due to haemorrhage, obstructed labour and sepsis were decreasing with the advancement of birthing techniques, mortality due to eclampsia was not.[36] In order to reduce maternal mortality attributable to eclampsia, earlier monitoring and interventions were necessary, during pregnancy, to identify high blood pressure and take steps to reverse it.[36] Antenatal care did not become common practice in developing countries until the second half of the 20th century.

Antenatal care can be defined as a collection of health monitoring and interventions intended to reduce morbidity and mortality for both mother and foetus during pregnancy and birth. Many of the interventions and monitoring tools in ANC were originally included with little evidence of the impact they had on maternal and neonatal outcomes.[36] Since the 1990s, many studies have been conducted to evaluate the relative benefit of the included interventions, especially in resource limited settings.[36–41] In 2001, WHO conducted a systematic review and trial of ANC interventions.[39,42] This research lead to the development of new guidelines for evidence based *focused antenatal care.*[37] The recommended elements of ANC include interventions shown to improve maternal and perinatal health outcomes, and perinatal

survival.[36,37] It is worth pointing out that maternal survival has been included as a secondary focus, due to the fact that approximately 75% of maternal mortality is the result of birth outcomes, such as haemorrhage, that are not addressed during ANC.[36,37]

The 2001 recommendations for ANC for non-complicated pregnancies (which require only routine care) include four visits during pregnancy; the first at 8-12 weeks gestation, the second at 24-26 weeks, the third at 32 weeks, and the fourth at 36-38 weeks.[37] The examination and interventions differ at each visit, and include:[37]

- Routine examinations of anaemia, blood pressure, and foetal growth monitoring
- Screening tests for common STIs (particularly syphilis and HIV), blood and urine tests
- Preventative measures of tetanus toxoid (TT) vaccination, iron, folic acid and IPTp
- Extensive maternal education and counselling on family planning, maternal and child nutrition, ITN use, alcohol and tobacco use, birth and emergency planning

Since the 1990s, over 70% of women have had at least one ANC visit during their pregnancy, worldwide.[36,37,43] The proportion of women attending ANC at least 4 times is lower and varies greatly by country, with the slowest improvements seen in sub-Saharan Africa, compared to Latin America and Asia.[37] Across countries, urban and educated women have the highest rates of at least 4 ANC visits.[36]

In November of 2016, the WHO released new ANC guidelines increasing the number of recommended ANC visits from four to eight, in an effort to improve maternity outcomes.[44] These newest ANC guidelines include 49 recommendations in the categories of: nutrition interventions, maternal and foetal assessment, preventative measures, interventions for physiological symptoms, and health systems interventions.[44]

Despite the increasingly prescriptive nature of ANC recommendations, and the inclusion of IPTp for malaria prevention during pregnancy, the guidelines produced neither in 2001 nor in 2016 explicitly recommend the distribution of an ITN as part of ANC services; (there is reference to ITNs in the footnotes of the ANC intervention table).[37,44] This has left individual national malaria control programmes responsible for the promotion and inclusion of ITNs in ANC services.

1.4. Integrated maternal and child health programmes

Before 2001, ANC consisted of a broad range of activities; the inclusion or exclusion of each intervention was decided largely by each country individually.[37] After the WHO systematic

review and development of the new model for ANC in 2001, the WHO's ANC programme recommendations became more prescriptive, globally, and included a wide range of disease prevention strategies as common practice.[42] The newest recommendations from 2016 build on that, developing a model for the delivery of comprehensive health interventions relevant to maternal and foetal health.[44] As a result, ANC is now described as "a vehicle for multiple interventions and programmes".[37,44] In sub-Saharan Africa, ANC includes malaria prevention strategies and HIV prevention interventions, thus making it, by nature, an integrated programme delivering maternal and child health interventions.[37]

The challenge with ANC is not the inclusion of these diverse interventions, but the time needed to deliver them. IPTp, for example, requires monthly visits to ANC, beginning in the second trimester, in order for a woman to receive the complete course of prophylaxis.[44] While the rates of women attending ANC at least once are very high, improved coverage of 4 or more visits is necessary to effectively delivery many of the included ANC interventions.

The EPI, by comparison, has been narrowly described as a programme with the goal of providing universal access to vaccinations.[29] The guidelines for practical implementation of EPI services do not include complementary interventions; they only provide details on vaccination delivery.[29]

The creation of the Millennium Development Goals (MDGs) placed new emphasis on the need for strong health systems and the benefit of integrated delivery of services.[45] The WHO and UNICEF developed the Global Immunization Vision and Strategy (GIVS) in 2005 which promotes the integration of maternal and child health programmes with EPI to improve community demand and coverage of immunization services, as well as supporting integrated programmes.[31] Since then there have been more than two dozen trials of maternal and child health services integrated with EPI, and there is a substantial literature on the topic. A major systematic review and subsequent update were published by Wallace et al, in 2009 and 2012, on "experiences integrating delivery of maternal and child health services with childhood immunization programs".[46,47] The review looked at programmes integrated with routine EPI, vaccination campaigns, and enhanced routine activities including child health days and vaccination weeks.[47]

Looking specifically at programmes integrated with routine EPI services, there are many published studies on the integration of a variety of interventions. These interventions include: LLINs,[48] IPTi,[12–14,49–53] HIV counselling and testing services,[54–56] hearing screenings,[57,58] nutrition

counselling and food suplimentation,[59,60] hygiene kit distribution,[61] and family health packages.[60,62]

The outcomes of interest for these studies vary, and include feasibility and utilization of EPI services, the care-takers' and/or health workers' opinion of integration, the cost of integration, or the coverage and timeliness achieved through integration. The most common outcome measured has been community or health workers' perception or response to integrated programming. Five of the studies assessing the outcome of community and health worker perception evaluated the integration of IPTi.[12–14,49,63] Community and health worker perceptions and opinions on acceptability were assessed using qualitative methods, through focus groups and in-depth interviews. The vast majority of studies, regardless of study setting, found that integration was favourably viewed by health workers and community members.[12–14,49,60,63] One paper evaluated the acceptability of HIV testing integrated with EPI found the programme was viewed positively by health workers, but noted that the stigma and need for confidentiality associated with HIV made the integration of these services more challenging.[54]

Integration's impact on coverage has also been evaluated in several studies. The specific evaluation methods differed between these papers, with varying degrees of rigour. Four papers looked at immunization coverage or vaccination schedule completion as an outcome;[48,61,62,64] the others included only coverage of the integrated programme.[51,54,57] Table 1 describes the integrated activities and the coverage-related findings from each study. In all these papers, measured coverage improved for either vaccination or the integrated programme, highlighting the potential benefit that integration can have on overall programme performance.

Table 1: Studies of integrated programmes and coverage outcomes

Author	Location	Date	Integrated programmes	Coverage Relationship
Ryman, et al[61]	Kenya	2012	Hygiene kits provided to families during immunization visits, by either nurses or community health workers	Vaccination (Penta 3) coverage increased with integration, from baseline to follow up, and to a greater extent in urban settings (63.4% to 74.7% rural; 71.9% to 90.7% urban).
Dicko, et al [64]	Mali	2011	IPTi was randomized to be given with EPI, or EPI services were delivered alone, to assess the impact of IPTi on immunization coverage	The coverage of a fully immunized child at 9-24 months of age rose from 36.7% to 69.5% in the intervention arm (compared to 53.8% in the control arm)
Igarashi, et al [62]	Zambia	2010	A broad program offering Vitamin A, deworming, family planning and health education was integrated with EPI in urban poor areas.	Immunization coverage improved from 52.6% to 68.8% from baseline to final survey. Odds of being fully immunized were 1.96 (95% CI: 1.28-3.00) times higher in the intervention arm compared to the lag-intervention arm.
Mathanga, et al [48]	Malawi	2009	Free ITNs were given to children who had completed the vaccine schedule by 12 months of age.	EPI: Completed vaccination schedule by 12 months increased in both intervention districts and the control district (49 to 69%; 33 to 63%; and 47 to 79% respectively). ITNs: The proportion of children using ITNs in the intervention arms increased significantly (14 to 40% and 10 to 44%), while the control arm did not see a significant increase (18 to 24%)
Kweku, et al [51]	Ghana	2009	IPTc (SMC) with EPI outreach compared to community based IPTc delivered alone	IPTc: Coverage when integrated with facilities doing outreach (EPI) was high 86%, but IPTc delivered alone was slightly higher at 90%. EPI integration misses the most hard to reach.
Rollins, et al[54]	South Africa	2009	HIV testing for maternal diagnosis and infant diagnosis with routine EPI	Early Infant Diagnosis: "More than half" of HIV exposed infants had confirmed HIV status, compared to 8% in routine care practice.
Olusanya, et al[57]	Nigeria	2008	Children under 3 months of age attending BCG clinics (75% of children who received BCG) were screened for hearing abnormalities	Hearing screening: 88% of all children vaccinated were given hearing screening; 100%, when screening services were on site. Target of 95% coverage in Nigeria

1.5. Continuous distribution of LLINs through ANC and EPI

Starting in 2011, the WHO and Roll Back Malaria (RBM) Vector Control Working Group (VCWG), produced recommendations and guidelines describing the need for programme implementation and evaluation of the continuous distribution of LLINs through ANC and EPI.[27,65,66] The recommendations noted that, while campaigns are the most efficient method for rapidly scaling up LLIN ownership, there needs to be a method to ensure a consistent stream of new nets enters communities to maintain coverage between mass campaigns.[65] ANC and EPI services were the recommended delivery platforms, as they achieve high coverage and target high-risk groups for malaria prevention: pregnant woman and infants.[65–67] The WHO recommendation states that, "Continuous distribution[c] channels should be functional before, during, and after the mass distribution campaigns to avoid any gap in universal access to LLINs."[68] The recommendation also states that every woman attending ANC and every child attending EPI should receive an ITN.[67,68]

WHO guidelines for the prevention of malaria in pregnancy (MiP) recommend both intermittent preventive treatment of malaria in pregnancy with SP (IPTp-SP) as well as delivery of an insecticide treated net during ANC visits. MiP has been an important branch of malaria control programming and research at both the global and local level.[69] In many countries education about ITN use, and in some places ITN distribution, were incorporated into ANC programming prior to the WHO malaria programme recommendation, due to MiP guidelines and the focused ANC programme developed in 2001.[37,69] As a result, more research has focused on the distribution of LLINs via ANC than via EPI.

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[c] It is important to note the diversity in terminology used for these programmes. When the WHO recommendation was released in 2011, the term "continuous distribution" was the most widely used term. Since then, other continuous distribution programmes, such as school-based distribution, have gained popularity, leading to the development of more specific terminology to distinguish one continuous system from another. Currently, the malaria control community uses various terms to describe this form of distribution. The term "facility-based distribution" is often used to refer to ITN distribution through ANC and EPI programmes that are conducted from health facilities. While less common, this term can also be applied to some types of campaigns which have used facilities as the primary distribution point for ITNs. "Routine distribution", by comparison, specifically describes the process of providing an ITN as part of a routine health service, as compared to campaign distribution, but does not distinguish where the routine service takes place. The most accurate term would be "routine continuous facility-based distribution", but as a working term, it is cumbersome. Within this thesis, a variety of terms have been used. In describing the history of the recommendation, the term "continuous" is used to align with the original recommendations. In the published results chapters of this thesis, "continuous distribution" was most often used, given the publication journals target audience and feedback from reviewers. In the other chapters of this thesis, the terms "facility-based" and "routine facility-based" are most often used, for consistency, and clarity of meaning.

1.5.1. Integration with ANC

There has been extensive research on the provision and use of malaria prevention strategies during pregnancy. The research focusing on ANC-based ITN distribution has utilized various methods, (such as pilot studies, cost analysis, cross-sectional surveys, and operational evaluations), and has evaluated the programme in terms of a variety of outcomes, (such as cost effectiveness, feasibility, equity, affordability, impact on ITN coverage and use, and operational barriers). Relevant systematic reviews have been published on the use of malaria prevention strategies, including ITNs, by pregnant women;[70] the factors affecting malaria prevention strategy access, including ITN access;[71] and a review and rationale for the prioritization of pregnant women in ITN distribution programmes.[72]

Before the advent of mass ITN distribution campaigns or the WHO recommendation for continuous distribution, research specifically investigating ITN distribution mostly evaluated subsidized for-fee systems, often involving vouchers.[73–79] Some studies at that time evaluated the potential benefits of free ITN distribution via ANC.

Four studies, resulting in 5 papers, examined the acceptability of, feasibility of and/or the coverage achieved through the free ITN distribution via ANC (Table 2). In 2002 and 2003, two papers by Guyatt et all, examined the free distribution of ITNs to pregnant women in Kenya.[80,81] The first paper looked at the cost, equity and feasibility of free ITN distribution through ANC, and found the programme to be favourable in all these respects.[80] The second paper analysed the use of ITNs as a result of the pilot and found that ITNs distributed free of charge were widely used by pregnant women and their infants after birth.[81] Similarly, a randomized control trial by Muller et al, in Burkina Faso in 2008 found that free ITN distribution through ANC increased ownership and use of ITNs.[82] A study by Beiersmann et al, in Burkina Faso, published in 2008, found that free ITNs distributed via ANC were well known and appreciated by community members in villages where free distribution was taking place.[83] In 2009, Pettifor et al, published a study which found that ANC-based ITN distribution increased ITN ownership and use among women during and after pregnancy.[84]

Three further studies published between 2009 and 2010, as well as the first Guyatt study mentioned above, specifically focused on the cost effectiveness of free ITN delivery via ANC, as compared to socially marketed ITNs (Table 2).[85–87] Though mass distribution campaigns were beginning to be implemented routinely at this time, none of these studies compared ANC-based free distribution with campaign distribution of ITNs. Yukich et al published a paper in 2009 describing a cost-effectiveness analysis of the Eritrean national ITN distribution

programme just after the introduction of free ITN distribution via ANC.[85] This study found that it was feasible and affordable to provide ITNs integrated into a health system, provided there was donor funding available for ITN costs.[85] Becker-Dreps modelled the cost-effectiveness of free ITNs distributed via ANC and found that they were highly cost effective at preventing DALYs, and lost years of life.[87] De Allegri, et al, in a study of the cost effectiveness of free ITNs vs socially marketed ITNs, published in 2010, found that free ITNs distributed via ANC were less expensive to deliver than supported socially marketed ITNs, further making the case for free ITN distribution and facility-based distribution.[86] Four of the six papers published at this time were primarily concerned with the cost-effectiveness of free ITN distribution via ANC.

These early studies assessing free ITN distribution via ANC supported the further expansion of this programme. The studies found ANC-based ITN distribution feasible, acceptable, and either highly cost-effective,[80,86,87] or reasonably cost-effective,[85] thanks to the use of an existing health system, and its resources.

Table 2: Studies of free ITNs distributed via ANC, before mass distribution of ITN was standard or facility-based continuous distribution was recommended

Author	Year	Location	Study objective	Findings
Guyatt et al.[80]	2002	Kenya	Evaluate the first free distribution of 70,000 ITNs, to ANC clinics in Kenya in 2001, purchased by UNICEF. No comparison group used	ANC-based ITN distribution had a low delivery cost, was equitable due to free distribution, was feasible due to the use of pre-existing services, and could strengthen ANC service delivery.
Guyatt et al.[81]	2003	Kenya	Evaluate the use of ITNs by pregnant women and infants after birth, when distributed free via ANC in Kenya (as above).	ITNs distributed via ANC were used by 84% of pregnant women and 91% of their infant in high transmission settings one year after ANC distribution had occurred
Muller et al.[82]	2008	Burkina Faso	Randomized control trial of free ITN distribution via ANC assessing ITN ownership. Compared to social marketing alone.	Free ITN distribution through ANC increased household ownership in the intervention arm from 13% to 35%. Ownership in the control arm increased much less (18% to 23%)
Beiersmann et al.[83]	2008	Burkina Faso	Qualitative study to evaluate community perception of different ITN distribution strategies	Free ITN distribution via ANC was well known and appreciated by the community members in village with free ANC-based distribution. Increased ANC attendance reported as a result of ITN distribution.
Pettifor et al.[84]	2009	DRC	Evaluate ITN use by pregnant women in the 6 months after the distribution of a free ITN via ANC Baseline ITN use was used as a comparison	Bed net use increased from 25% of women before free ITN distribution to 79% and 80% at the time of distribution and 6 months after, respectively.
Yukich et al.[85]	2009	Eritrea	Evaluate the cost and cost-effectiveness of Eritrea's national ITN distribution strategies. Previous distribution strategies and similar studies were used as comparison.	Free ITNs via ANC were cost effective, provided donor funding was available for ITN purchase. Introduction of LLINs would see a drop in operational costs because retreatment campaigns would no longer be required.
Becker-Dreps et al.[87]	2009	modelled	A decision tree model used to assess the cost of free ANC-based ITN distribution in DRC	ITN distribution is a cost effective addition to ANC services: ITNs would cost $17.22 per DALY averted (95% CI: $8.54-$30.90), or $15.50 per life-year saved (95% CI: $7.65-$27.68)
De Allegri et al.[86]	2010	Burkina Faso	Measure the cost-effectiveness of free ITNs distributed via ANC services. Socially marketed ITN distribution was used as a comparison	ITNs distributed via routine ANC were more cost effective than ITNs distributed via social marketing due to the use of existing systems and resources in place for routine health service delivery.

By 2010, free mass distribution campaigns had become the dominant distribution strategy recommended by the WHO, thanks to the development of LLINs, the success of mass distribution trials, and the available funding from the Global Fund. Most research evaluating

ITN distribution at this time was looking at mass distribution campaigns.[88–93] Early campaigns focused on ITN distribution to households with children under 5 years, and pregnant women, and often capped ITNs distributed at one or two ITNs per household.[23,25,26,73,94–97] Few studies compared mass distribution to facility-based ITN distribution, however two studies, both published in 2010, looked at the cost-effectiveness[98] and the ITN ownership[99] as the result of mass campaigns as compared to ITNs distributed via ANC services (Table 3). In both of these studies the campaigns targeted households with pregnant women and children under 5. Kolaczinsky et al. reported that ITN distribution was more expensive through ANC as compared to campaigns, but noted that this was at least partially due to the short period of time that ANC distribution had been in place.[98] Larsen et al. identified an important challenge of targeted campaigns, namely that households without pregnant women and children were at a disadvantage and were less likely to have ITNs after these campaigns.[99]

Table 3: Facility-based ITN distribution via ANC after the standard use of mass distribution campaigns

Author	Year	Location	Study objective	Findings
Kolaczinsky et al.[98]	2010	Uganda	Analysis of the cost effectiveness of ITNs distributed via mass distribution compared to routine ANC services.	More ITNs were used by women and children when distributed via ANC compared to campaigns. Economic cost of ITNs delivered via campaigns was less than those delivered through ANC.
Larsen et at.[99]	2010	Zambia	Evaluation of net ownership in communities with mass ITN distribution campaigns targeting children <5 and routine facility-based ANC distribution.	Households with children < 5 years are more likely to have an IT from a campaign than households without (OR=2.43, 1.67-3.55). Households with a woman who has attended ANC in the last 2 years are more likely to have an ITN than households without (OR=1.52, 1.04-2.21)

In 2011, the Roll Back Malaria Monitoring and Evaluation Reference Group produced a recommendation for new vector control indicators, one of which was “the proportion of the population with access to an ITN within their households”.[100] The new indicator along with research like that by Larsen et al. (presented above), shifted the focus of mass distribution campaigns away from target groups and towards “universal access”, defined as one ITN per two people per household.

The WHO recommendations for continuous distribution developed around the same time, to ensure continuous ITN distribution to the high-risk groups of pregnant women and children. At this point, the focus of facility-based ITN distribution research shifted away from cost-

effectiveness, and towards details of feasibility, coverage and acceptability of integrated service delivery. Four papers by Webster and Hill, published between 2013 and 2014, assessed the feasibility and effectiveness of ANC as a delivery platform for both ITNs and IPTp (Table 4). The primary focus of these papers was on IPTp implementation, with the bulk of the research findings focusing on the effective delivery of three doses of SP during pregnancy. These four papers also assessed ITN distribution, and show that ITN delivery via ANC is effective and acceptable, and generally easy to acheieve.[101–104] The main challenges identified for ANC-based ITN delivery were stock out of ITNs,[101] and inconsistent distribution by health workers.[104]

Table 4: Studies of ANC-based ITN distribution, published after the WHO continuous distribution recommendations

Author	Year	Location	Study objective	ITN Findings*
Webster et al.[101]	2013	Mali	A cross-sectional study in 10 health facilities of 780 pregnant women was conducted to assess the proportion of women to received malaria prevention interventions during ANC: IPTp and ITNs.	ITN delivery was effective when ITNs were in stock. Stock outs were a problem. When ITNs were in stock, approximately 80% of pregnant women were offered an ITN, of which over 90% accepted.
Webster et al.[104]	2013	Mali	In-depth interviews were conducted with health workers at national, regional, and district level to report on ANC malaria prevention practices, and identify reasons for the ineffective delivery of these services.	The most common reason identified for not providing an ITN to pregnant women was if the woman was from outside the catchment area. The other main problem identified was distribution issues leading to stock-outs.
Hill et al.[102]	2013	Kenya	Two-stage cluster sampling household survey was conducted to assess the effectiveness of ANC to delivery IPTp and ITNs to pregnant women.	76% of pregnant women using an ITN received it from an ANC visit. Of women who attended ANC, and used an ITN, 80% received the ITN from and ANC visit.
Hill et al.[103]	2014	Mali	Two-stage cluster sampling household survey was conducted to assess the effectiveness of ANC to deliver IPTp and ITNs to pregnant women.	93% of pregnant women reported using an ITN the previous night, and 81% of those women reported receiving the ITN from an ANC visit. 74% of women who had previously had a pregnancy reported obtaining the ITN used during pregnancy from ANC

* IPTp findings excluded from the table

1.5.2. Integration with EPI

Only two studies, resulting in three papers, have looked specifically at the integration of LLINs with EPI programmes (Table 5). The first study by Mathanga et al, conducted before the programmatic shift towards mass campaigns, and before recommendations for routine facility-based distribution, evaluated the distribution of ITNs through a routine EPI programme.[48] The paper theorized that if ITN integration with vaccination campaigns were useful then

integration with routine services would have a similar effect. Mathanga et al describe a pilot study conducted in Malawi to evaluate integration's impact on the coverage of both ITNs and the routine vaccination visit used for distribution – in this case Measles vaccine.[48] The pilot conducted the intervention in two districts, providing nets with the completion of the EPI schedule at the measles vaccination visit, and used one district as a control, where ITNs were for sale at a subsidized cost, in line with the national policy. The study found that ITN ownership and use increased significantly for children 12-23 months of age in the intervention districts and not at all in the control districts, and that immunization coverage was not adversely affected.[48]

Two later papers describe one study on integration perceptions and time to deliver integrated services, and included LLINs as one of a collection of integrated services. These studies were conducted after the WHO recommendation for integration ITN delivery via facility-based programmes, and the WHO support of EPI integration. The study was conducted in Mali, Ethiopia, and Cameroon, and used direct observation, focus groups and in-depth interviews.[60,105] One paper focused on community and health worker perceptions, and looked at method of integration, satisfaction with integration, and challenges. Across countries integration was viewed favourably by both community members and health workers.[60] In Mali, ITNs were seen to improve vaccination coverage as an incentive to come to a 9 month visit.[60] Integration was also preferred by mothers who wanted high-impact visits, and short delivery time.[60] In all three countries stock-outs, health worker capacity and time availability were express concerns with integration.[60] In Mali, there was specific concern that stock-outs would negatively impact vaccination coverage, as mothers would be disappointed with the lack of integrated services and not return for immunizations.[60] In Cameroon, extra focus was put on the stress of workload and the inadequate time needed to perform all the tasks.[60]

The same study resulted in a second paper reporting on the observed time and activities required for service delivery, with LLIN observations included for Mali and Cameroon. On average, it took 5:52 minutes (95% CI: 1:52, 7:12) to distribute an ITN.[105] By comparison, infant vaccination took 2:22 minutes (95% CI: 1:39, 3:38).[105] The study found that health staff consistently overestimated the time it took to deliver integrated services, reporting on average ITN distribution would take 16:48 minutes.[105] The study also reported that updating registers required 32% of the time taken to distribute a ITN, but did not give further details on what records were being kept.[105]

Table 5: Studies of EPI-based ITN distribution

Author	Year	Location	Study objective	Findings
Mathanga et al.[48]	2009	Malawi	Pilot study to evaluate the feasibility of ITN distribution via EPI, and assess the increase in ITN use and vaccination coverage due to integration. Control district used	ITN coverage doubled in the two intervention districts, and did not increase in control district. Vaccination timeliness and coverage increased in all three districts.
Ryman et al.[60]	2012	Mali, Cameroon, Ethiopia	Qualitative interviews with health workers and community focus groups conducted to understand perceptions and acceptability of EPI integration	Integration was well accepted and encouraged by health workers and community members. Concerns were raised about stock-out and delivery time required.
Wallace et al.[105]	2012	Mali, Cameroon	Observed delivery of EPI and integrated services to assess true time required and health worker perceptions of time required.	ITN delivery took longer than vaccination delivery on average. Health workers overestimated the amount of time needed to provide each service.

1.5.3. Facility-based integration

Five papers, two of which measure coverage, and two of which are models, have investigated the distribution of ITNs through both ANC and EPI (Table 6). Two studies published in 2011 looked at household ownership of ITNs distributed via ANC and EPI. In the first study, by Skarbinski et al, the coverage achieved as the result of facility-based ITN distribution in Malawi was evaluated via a cross sectional survey in 8 of 28 districts where campaigns had rarely been implemented.[106] It found that households with either a child under-5 or a pregnant woman had the highest ITN ownership at 73% (95% CI: 70%-75%), compared to households with neither, at 55% (95% CI: 50-60%).[106] Interestingly, thirty-six percent of households that were ineligible for an ITN via facility-based EPI or ANC distribution owned a net obtained from this channel, suggesting that nets are shared beyond the original distribution target and household.[106] The second study by O'Meara et al, assessed household ITN ownership in an area of Kenya with facility-based ITN distribution, but without mass distribution campaigns for more than five years.[107] This study found that rural households with pregnant women and children were more likely to own a mosquito net (OR= 1.22 and 1.21 respectively) compared to household without these target groups.[107]

An analysis from 2011, by Carlson et al., investigated the overlap in coverage of ANC and EPI, to assess if the two programmes would deliver ITNs to the same families or different families.[108] The assumption in this paper was that for ITN distribution to be beneficial through both channels, the programmes would need to reach different populations.[108] They found that

there was significant overlap in the mothers who attended ANC and those who attended EPI, but did note that there could be some added gains from including both programmes as distribution channels.[108] While this is the only paper that explicitly discusses the theory that ITN distribution via ANC and EPI combined may be redundant, it reflects a common sentiment of the time.

Two further studies modelled the possible ITN coverage outcomes as the result of different distribution strategies. The first, by Okell et al, published in 2012, investigated the potential child deaths averted as the result of different distribution strategies and combinations of strategies in low, medium, and high malaria transmission settings.[109] The study considered two types of campaigns and facility-based distribution through both ANC and EPI.[109] The model found that the greater the number of delivery channels included, the more deaths would be averted. But, it noted that the efficiency of the lives saved per ITN distributed decreased with the addition of many channels due to the overlap in target household.[109] This paper also found that distribution via EPI prevented more under-5 deaths than ANC, due to the older age of the malaria burden in this population.[109]

The second model, published in 2013 investigated the potential coverage achieved from a variety of different distribution strategies for overall ITN ownership and use, in Tanzania.[110] In this paper ANC and EPI were combined as one distribution strategy.[110] The Tanzanian authorities favoured a subsidized voucher programme, and as a result this model did not consider the combination of free ITNs through routine channels with campaign based distribution.[110] This study found that school-based voucher distribution, offered in primary school years 1, 3, 5, and 7, and secondary school years 1 and 4, was more effective at increasing community net ownership than any other distribution strategy.[110] Despite the findings presented in the Skarbinski paper, neither of the models considered the reallocation of ITNs distributed via ANC and EPI to households without pregnant women or infants, which may increase the potential coverage and impact achievable through this distribution strategy.

Table 6: Facility-based ITN distribution studies combining ANC and EPI based distribution

Author	Year	Location	Study objective	Findings
Skarbinski et al.[106]	2011	Malawi	Household cross-sectional survey was conducted to assess ITN ownership and use as a result of facility-based distribution	The highest net ownership was in households with pregnant women or children present. ITNs distributed via ANC and EPI were found in homes without children and pregnant women.
O'Meara et al.[107]	2011	Kenya	Cross sectional household survey conducted in area without any campaigns to assess the reach of facility-based distribution strategies.	Households with children under five (OR=1.21) or pregnant women (OR=1.22) were more likely to own ITNs than households without.
Carlson et al.[108]	2011	Model	Used DHS data to determine the factors associated with attending ANC and EPI, to predict potential overlap of ITNs distributed via these channels	Attendance of ANC and EPI are not independent. Many ITNs would reach the same families if both distribution channels are used.
Okell et al.[109]	2012	Model	Modelled impact of different ITN delivery strategies, as stand-alone or combined options, in low, medium, and high transmission settings.	Increased delivery channels resulted in more death averted, but less efficient lives saved per net. EPI-based distribution prevented more childhood deaths than ANC-based distribution.
Koenker et al.[110]	2013	Model	Modelled possible distribution strategies for Tanzania based on the National Malaria Control Programme's interests and needs	Found ANC and EPI distribution combined to provide modest gains in coverage, compared to school based distribution.

Since 2002, there have been at least twenty studies assessing the feasibility, acceptability, cost-effectiveness, coverage, and potential lives saved as a result of free facility-based ITN distribution. The majority of these studies assessed free distribution via ANC, before the common practice of free mass distribution campaigns or the WHO recommendations for facility-based ITN distribution. The findings of these studies have shown that free ITNs via ANC and EPI are easily distributed, cost-effective thanks to the establishment of the routine systems with which they are integrated, and are encouraged by both health workers and community members.

Very few studies, by comparison, have evaluated ANC and EPI-based distribution combined. The two studies which directly assessed ITN ownership as a result of facility-based distribution found that households with pregnant women and children were more likely to own ITNs.[106,107] Neither of these studies reported an oversupply of ITNs to some households as a result of combined ANC and EPI distribution strategies.[106,107] Despite this, the models investigating

facility-based distribution have been concerned with the overlap of the household targeted by these two channels.[108–110]

The published research on these distribution channels has not yet looked at the operational difference between ANC and EPI, as delivery platforms. Nor has there been an analysis of the household ownership and use from the implementation of both distribution channels as compared to just one, though one model did include this as a prediction.[109] The research presented in this thesis aims to fill some of these gaps in knowledge, to expand our understanding of how routine facility-based ITN distribution systems contribute to malaria prevention strategies.

CHAPTER 2: RATIONALE, GOALS AND OBJECTIVES

2.1. Rationale

Before mass campaigns became common practice for the distribution of ITNs, research had identified routine facility-based distribution as an important potential strategy to increase ITN ownership and use. This research focused mainly on ANC-based distribution compared to payment-based systems, which charged either full or subsidized prices for ITNs, and found free facility-based distribution to be equally cost effective and efficient at increasing ownership and use among pregnant women and their infants.

Thanks in large part to the new availability of ITNs through the Global Fund, starting in the first decade of the 2000s malaria programmes shifted the focus from high-risk groups, such as pregnant women and children, towards all individuals, promoting "universal coverage" aimed at the entire population living in malaria endemic zones. This, along with the effectiveness of the first ITN distribution campaigns shifted attention towards campaigns as the primary distribution strategy to improve and maintain ITN ownership and use. Routine facility-based ITN distribution was promoted less, especially in the case of distribution via EPI, which had been emphasized less in research up to that point in time.

In 2011, the WHO and RBM switched attention back to the biologically vulnerable groups of pregnant women and children in addition to the goals of universal coverage, and formally recommend the distribution of ITNs via ANC and EPI, in addition to campaigns, in an effort to ensure coverage of these vulnerable groups, and to maintain and improve coverage in between campaign distributions.

Since the early 2000s both ANC and EPI programmes have advocated for more integration in maternal and child health services, noting the benefits to both the integrated services and the existing programmes of ANC and EPI. This has created an atmosphere, at the international level, that is welcoming to integration for health promotion and disease prevention. As a result, integrated maternal and child health services have become more common, but significant challenges still exist across countries and programmes, identified in operational research. There has also been concern raised over the potential burden or strain that may be caused by integration, to the existing programmes, when other services are added. While ANC and EPI are both routine programmes, their structures differ, and they have presented different approaches to, and strategies for, integration.

National Malaria Control Programmes (NMCP) have been increasing routine facility-based distribution programmes for ITNs in recent years, but there has been little information on the breadth and reach of these programmes. While previous research has demonstrated that routine facility-based ITN distribution programmes are feasible and acceptable, and improve ITN ownership and use, there has been little operational research on the experiences of the national programmes, addressing the strengths and weaknesses of these distribution strategies. The methods used to evaluate the success of ITN distribution programmes typically focus on ITN ownership and use within households, without considering the distribution channel or source of ITN. Because of this, there are few routine indicators available to assess the successful service delivery and uptake of ITNs through the routine channels of ANC and EPI.

As routine facility-based distribution of ITNs is adopted more broadly, and becomes more common, questions arise about their implementation:

- How broadly are these programmes being implemented?
- What challenges or best practices exist across countries that can guide other countries in implementing these programmes?
- How do ANC and EPI differ as integration platforms, and does that have an impact on ITN distribution?
- Now that campaigns are common practice in most countries, do routine facility-based distribution strategies still significantly increase ITN ownership and use?
- Do ANC and EPI programmes benefit from ITN integration?

The research presented in this thesis contributes to the literature on routine facility-based distribution of ITNs, with special attention paid to the combination and comparison of ANC and EPI as distribution strategies. This thesis gathers information on the routine implementation of integrated ITN distribution through ANC and EPI, and presents an analysis that highlights the strengths and weaknesses of these delivery systems.

Given that the source, or distribution channel, through which a family received an ITN is not routinely collected as part of standard ITN coverage measurements, this thesis utilized a mixed methods approach to draw on a variety of techniques to assess these ITN distribution programmes. By using mixed methods it is possible to approach the problem from different angles to understand a variety of challenges and barriers to routine implementation.

These distribution strategies are being adopted and implemented. The evaluation of these programmes is essential, to understand their strengths and weaknesses and to ensure they are as effective as they can be. In many cases, these programmes are being implemented without evaluation, and so adding to the literature on best practices, from policy to coverage, can provide countries with important information to strengthen their malaria prevention programmes.

2.2. Goals

- To contribute to the knowledge on routine facility-based distribution of ITNs via ANC and EPI, with the intention to improve the strategies for these distribution channels
- To achieve this through a better understanding of current routine facility-based distribution policies, programmes, implementations, and use, as well as through a comparison of routine ANC and EPI programmes as service distribution platforms

2.3. Objectives

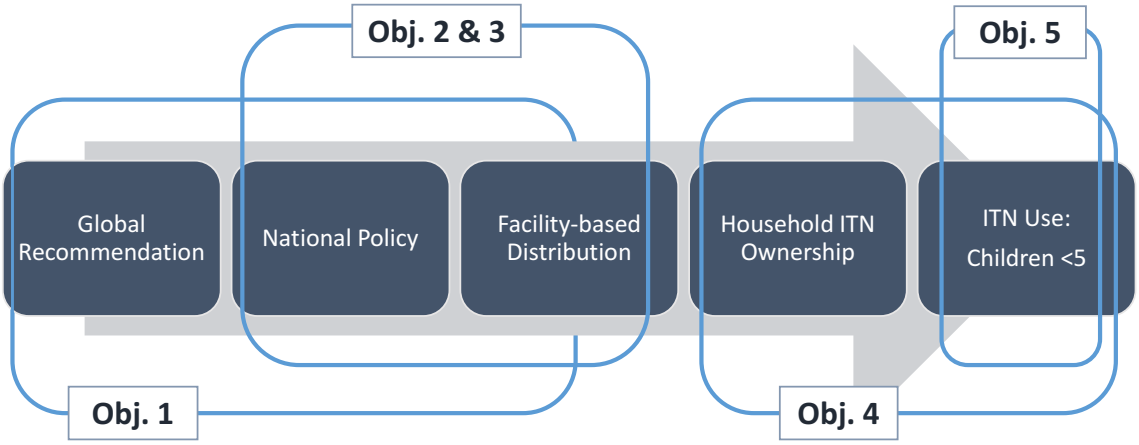
1. To analyse the availability of LLINs through routine channels, and assess the missed opportunities for ITN distribution to women and children through these channels
2. To evaluate the implementation of routine facility-based distribution policies, and identify operational challenges, best practices, or bottlenecks that might be present
3. To evaluate routine ITN distribution via ANC and EPI programmes and describe the differences between ANC and EPI as platforms for LLIN distribution, to learn from the strengths and weaknesses of these programmes
4. To analyse the impact of routine facility-based distribution policies in Africa on household net ownership and net use by children under-five years of age
5. To investigate the effect that facility-based ITN distribution has on the coverage and equity of ANC, EPI and LLIN use, to identify the potential benefits and/or drawbacks of integrated delivery of ITNs via ANC and/or EPI, in terms of coverage and equity, for each integrated programme

Figure 2 illustrates the process by which routine facility-based ITN distribution goes from an international recommendation to a national policy, which is then implemented at the facility level, and ultimately increases household ITN ownership, with the intention of increasing ITN use in children under 5 years. Beginning with a global recommendation (in the left-most box),

a series of policy, implementation and individual use actives should occur to increase childhood ITN use, and ultimately decrease malaria (not included in the diagram).

The research undertaken for this thesis focused on this entire process to understand what barriers and bottle-necks might occur at each step. In the figure, the focus of each objective is circled. The results chapters presented in this thesis (chapter 4-8) each address a single objective. A version of this figure will appear at the beginning of each results chapter to illustrate the level of the health system being evaluated, and provide a description of how each section fits into the overall thesis.

Figure 2: Visualisation of the process through which a global recommendation leads to increased ITN use in children, and the elements of that process included in this thesis



ETHICS

The work presented in this thesis was reviewed by academic ethics review boards, and granted ethics approval. For the fieldwork in this PhD, ethics approval was granted by the London School of Hygiene and Tropical Medicine, the Johns Hopkins Bloomberg School of Public Health, and the National Malaria Control Programmes in Kenya, Malawi, Mali, and Rwanda. The quantitative secondary dataset analysis was conducted using the Demographic and Health Surveys (DHS) in 25 countries, with access granted by the United States Agency for International Development (USAID). Ethics approval for the DHS analysis was granted by the London School of Hygiene and Tropical Medicine. All relevant ethics approval letters can be seen in Appendix A.

CHAPTER 3: METHODS

Each of the results chapters presented in this thesis includes a methods section relevant to that piece of research. As a mixed methods PhD, a variety of methods, including qualitative, quantitative, and health economics tools were used. The information included in this section gives more detail than would typically be seen in a research paper for publication. Specifically, more information is provided here about some of the key theories, methods, and datasets considered and used in this project.

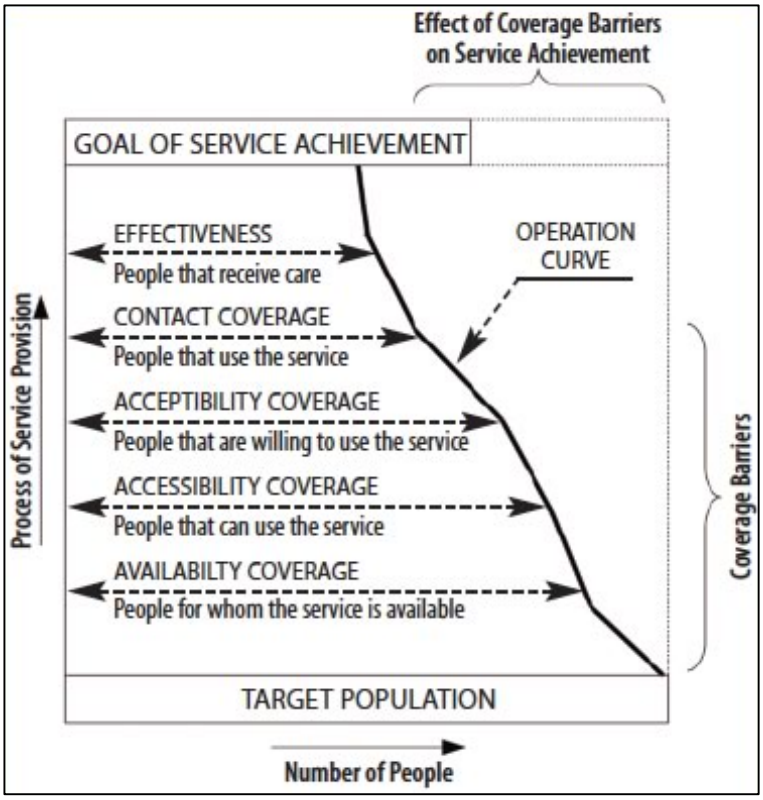
3.1. Measuring Coverage

"Coverage" is a common measure, applied to many health programmes, to assess progress, set targets, and monitor and evaluate the success of many services within and outside of public health. Coverage is often defined as a single point estimate to allow a quick understanding of the scope or reach of a programme within a population. Broadly, ***coverage has been used to describe the proportion of a target population that has received a given service***.

In 1978 Tanahashi described the measurement of coverage for health services[111]. Before Tanahashi's paper was published, the term "coverage" had been used in public health evaluation, but far less frequently than it is today. Notably, in the 1950s and 60s, "coverage" was often used to literally describe the wall cover achieved through DDT spraying in households, for malaria prevention.[112,113] By the 1970s, the term "coverage" was appearing in more research, especially in reference to the reach of general health services, but was still relatively uncommon.[114,115] Tanahashi was the first to systematically describe the metric and its application in public health, broadly. Tanahashi advocated for its routine use in programme monitoring.[111] In his paper, Tanahashi broke coverage down into five categories (*Figure 3*):

1) Availability coverage, of the people or whom the service is available;
2) Accessibility coverage, or the people who can use the service;
3) Acceptability coverage, or the people who are willing to use the service;
4) Contact coverage, or people who use the service; and
5) Effectiveness coverage, or people who receive effective care.

Figure 3: Tanahashi coverage diagram (1978)



Published in the Bulletin of the World Health Organization, 56 (2): 295-303 (1978)

Tanahashi's categories 1-3 represent the potential coverage a programme might achieve, while categories four and five represent actual coverage as a result of implementation.[111] Tanahashi proposed that these definitions be used together, wherever possible, to maintain consistency in reporting and to monitor health programmes and support the identification of bottle-necks in implementation.[111] An important feature of Tanahashi's description of coverage is the step-wise loss of coverage seen with each subsequent category. This visualisation clearly demonstrates how small losses in coverage at each step can add up to a significant decrease in "effectiveness coverage", even if each step was fairly efficient.

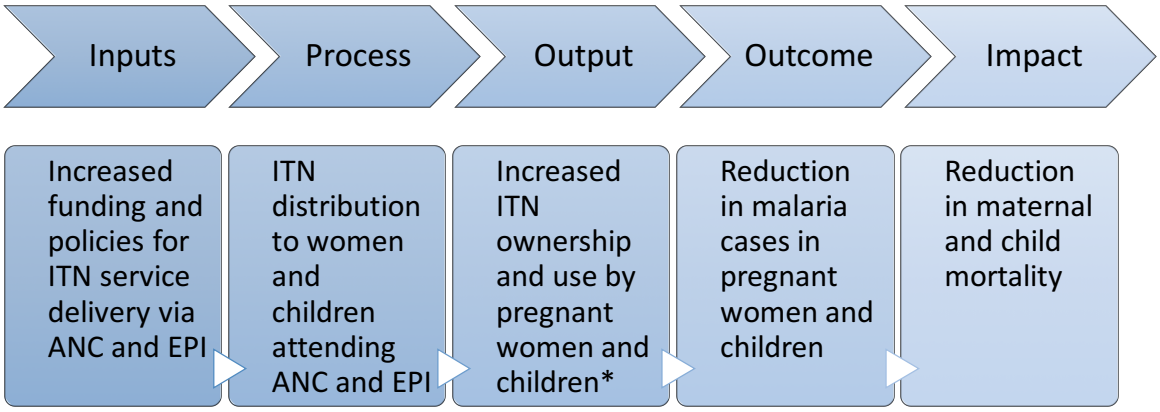
Coverage has become a common measurement for programme evaluation, but despite Tanahashi's efforts, most programmes report a single coverage estimate, which most closely represents Tanahashi's fourth statistic (or measure): Contact coverage. Most of these coverage statistics represent population level estimates. *Table 7* identifies a few official coverage definitions from WHO and UNICEF for different public health programmes.

Table 7: Standard coverage definitions for public health programmes

Programme	Coverage Definition
Antenatal care coverage (at least one)	"The percentage of women aged 15-49 with a live birth in a given time period that received antenatal care provided by skilled health personnel (doctors, nurses, or midwives) at least once during pregnancy."[116,117]
Antiretroviral therapy coverage among pregnant women (PMTCT)	"The percentage of HIV-infected pregnant women who received antiretroviral medicines to reduce the risk of mother-to-child transmission, among the estimated number of HIV-infected pregnant women."[116]
Vitamin A coverage in children 6-59 months	"Proportion of children aged 6–59 months who received a high-dose vitamin A supplement within the last 6 months."[116]
DTP3 coverage (%)	"The percentage of one-year-olds who have received three doses of the combined diphtheria, tetanus toxoid and pertussis vaccine in a given year."[116]
Prevalence (coverage) of condom use by adults 15-49 (%)	"Percentage of women and men aged 15–49 who have had more than one sexual partner in the past 12 months who report the use of a condom during their last sexual intercourse"[116]
Contact coverage of mental health programmes	"The proportion of persons in need of a service (e.g. the number of cases with diagnosable disorders such as schizophrenia or depression) who receive an intervention that is appropriate to their condition"[118]
Safe drinking water coverage	"The proportion of population with sustainable access to an improved drinking water source, urban and rural"[119]
ITN Coverage	1) "The proportion of population with access to an ITN within their household"[120] 2) "The proportion of individuals who slept under an ITN the previous night"[120]

These types of coverage indicators generally represent public health "outputs": immediately measurable results, representing the direct deliverables of a project.[121,122] These outputs are often used to estimate potential "outcomes" (the changes that will occur as a result of the output, and the individuals that will benefit) and "impact" (the broad improvements that are the ultimate goals, not solely achievable through the project itself) that may result, especially when the measurement of the outcomes and impact are difficult due to funding or timeframe constraints.[121,122] Funding agencies, such as the UK Department for International Development (DFID) and The Gates Foundation, often request implementers to use a Logical Framework Approach (Log Frame) to identify the outputs, outcomes and impacts expected as a result of funded projects.[122,123] An example of a Log Frame for routine facility-based ITN distribution via ANC and EPI can be seen in *Figure 4*.

Figure 4: Example Logical Framework Approach for ITN distribution via ANC and EPI



* Based on previous research, one could argue that the output of these programmes would be a population level increase in ITN use, resulting in population level outcome and impact measures, beyond pregnant women and children. For this example, a more narrowly defined programme output has been described.

Even with a clearly defined coverage measure, both the numerator and denominator can be difficult to estimate, depending on the context. For example, a systematic review of mental health programmes found that a variety of source data, producing a wide range of estimates, were used to calculate the denominator of *persons in need of service*, including: "surveys to estimate the prevalence of a disorder," "prevalence rates taken from a review of global literature," and "use of a local register of … addicts kept by the police department."[118] Numerators can be just as challenging. In the research area of water and sanitation, estimating *sustainable access* to improved drinking water, often takes "quantity, quality, proximity, reliability, price, and affordability" into consideration.[124]

The primary coverage statistic for most health programmes, like those in *Table 7*, typically represents a population level analysis. Many programmes use additional coverage estimates to addresses heterogeneity within populations. District or regional immunization coverage, for example, aims to identify the proportion of districts (or regions) with immunization coverage above a given level, ensuring that all districts meet the target coverage level[30]. By targeting 80% coverage in 80% of districts, for example, country programmes ensure there is a focus on improving coverage across the nation.[30] Similarly, in an effort to focus on improved saturation of ITN ownership within a country, following a 2011 WHO and Roll Back Malaria call for "universal coverage", a new household ITN ownership indicator was proposed, aiming to identify "The proportion of households with at least one ITN for every two people".[66,120,125] This new indicator also helped to interpret low ITN use measures, identifying households and

communities where there were not enough ITNs per household to meet the needs of the household members.[125]

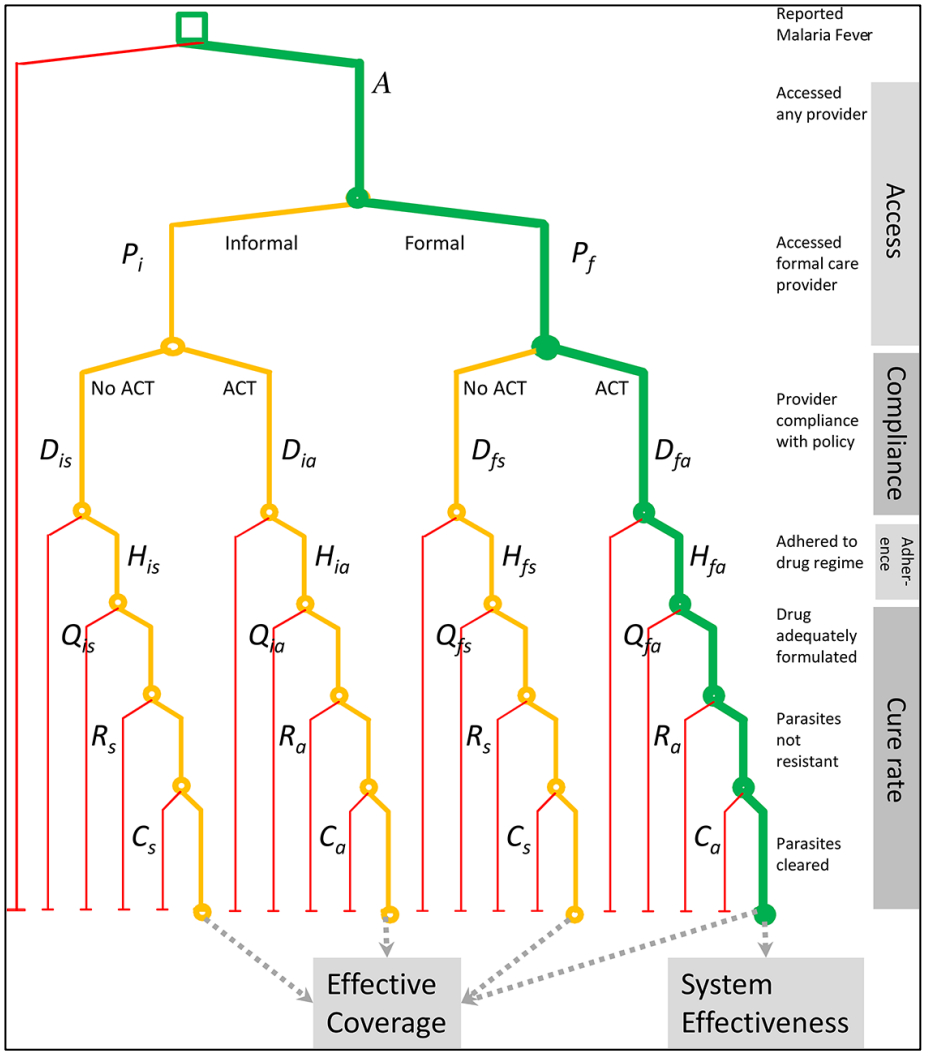
In the field of literacy, Basu et al. went one step further, challenging the standard literacy rate (percentage of total adults who are literate). Basu et al. argued that proximity to a literate person provides some benefits of literacy to those illiterate people around them, and that this should be taken into consideration .[126] The argument continues that a society in which literacy is more evenly distributed is better off than one in which literacy is highly concentrated. Examples are given of such indirect effects, including the ability to access health services advertised in posters, or gain farming information from a pamphlet.[126] To address this, Basu et al. created an alternative literacy measurement that takes account of an individual's proximity to a literate person.[126] In the simplest explanation, Basu et al. calculates the effective literacy as the proportion of individuals with literate household members, according to which a greater proportion of literate individuals in a household results in a higher literacy score for all household members.[126]

This interpretation of "coverage", which could also be described as a coverage density measure, incorporating an indirect effect, is not unique to literacy alone. Vaccination programmes calculate the *total effect*, or *herd immunity* which accounts for both the direct protection a vaccinated individual experiences as well as the indirect protection all individuals experience as the result of reduced transmission (and increased protection) within a community. [30,127] A further *herd immunity threshold* is the theoretical level of coverage above which the incidence of disease will decrease over time towards zero.[30,127] The interpretation of this threshold is complicated because vaccination coverage is typically not homogeneous across a population. Considerations of vaccination heterogeneity, such as the calculations of district level coverage mentioned above, are valuable when measuring or estimating herd immunity because the minimum threshold must be maintained in all areas to achieve the predicted reduction in transmission.[30,127] Malaria researchers have also investigated the *mass effect* of ITN coverage, whereby individual coverage also leads to increasing levels of community protection as the result of declining in malaria infection incidence.[128] This community protection can be seen at levels as low as 50% individual coverage, with increased community protection for those not sleeping under a net as ITN ownership and use in the community increases.[18,128] These coverage measures look beyond individual protection to community based protection.

The distinction between *efficacy* and *effectiveness* can also lead to different calculations of coverage, based on the assumptions behind these terms. "Efficacy" refers to the results of an intervention under ideal conditions with perfect uptake and follow-up for all participants, generally measured in randomized control trials (RCT), especially evaluating drugs or vaccines.[129] "Effectiveness", by comparison, measured in observational studies, refers to the results of interventions when implemented under "real world" conditions, with varying levels up uptake, adherence, and use as directed, for an intervention.[129] In 1996, the seminal paper by Clements et al. argued that for vaccine research, especially in developing countries, measuring effectiveness, rather than efficacy, could more "comprehensively address outcomes of public health concern".[130]

Researchers evaluating drug use and effect in the treatment of malaria have also used the term "effectiveness", but with a different definition. Specifically, "system effectiveness" measures the proportion of events effectively treated by the formal health services.[131,132] In this scenario, system effectiveness requires: access to a formal care provider, provider compliance with treatment policies, patient adherence to drug regimen, correct drug formulation, no parasite resistance to the drug, and the effective clearance of parasites.[131] By comparison, "effective coverage" measures the same outcome, but for individuals in formal and informal care settings, with and without provider compliance to policies.[131] An illustration of these measures can be seen in Figure 5. This type of coverage and effectiveness decision-tree could be adapted to other treatment programmes, beyond malaria.

Figure 5: Decision tree model for case management of uncomplicated malaria



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Unlike “prevalence” or “incidence”, the term “coverage” does not have a single and obvious definition across health programmes and settings. Many health programmes, like those discussed above, have developed specific coverage terms and definitions to meet the needs of the interventions, populations, and infections/conditions being measured. These terms might be well understood within a field of study, but virtually unknown to scientists in another field. While the variety and specificity of coverage measures allow researchers to be precise in their analysis, and look at coverage in different ways, it can also lead to confusion, especially for those outside the field, depending on how well the measures are defined and presented. The research presented in this project focused on a comparison of three specific health programmes (EPI, ANC and LLINs), and their coverage across multiple countries. In order to

make valid comparisons between these programmes, it is necessary to understand the coverage measures, terms and definitions used in each programme.

3.1.1. ITN programme coverage

ITN programmes use multiple coverage indicators to track both ownership and use of ITNs. The variety of coverage measures allows malaria researchers to assess different aspects of ITN programming. Because there are a larger number of coverage measures used in ITN programmes, as compared to others (such as ANC and EPI discussed below), it is important to understand why these different indicators are needed, and to be explicit about their definitions and implications, to avoid confusion.

The seminal and first national integrated ITN and vaccine campaign which took place in Togo in 2004, for example, conducted two cross-sectional surveys of eligible children and their households one month and nine months post-campaign.[23] Within the published article describing this programme, five different coverage statistics were identified in the abstract alone, representing slightly different definitions of the numerator, denominator, and/or time-frame of evaluation, and ranging from 43.5% (eligible children using an ITN one month post campaign – dry season) to 93.1% (eligible children who had received a net during the campaign, evaluated one month post campaign).[23] Other coverage estimates included evaluations nine-months after the campaign, general household ownership of at least one net, and seasonal variation in usage.[23]

Despite the large variety of coverage measures found in some studies, like those listed above, the WHO and other global partners have used three ITN coverage measures as standard since the mid-1990s, enumerating ITN ownership and use. In 2011, the Monitoring & Evaluation Reference Group (MERG) of Roll Back Malaria (RBM) first proposed "access measures", in addition to the standard ownership and use measures.[8,133] These new "access measures" were subsequently adopted by WHO for the 2012 World Malaria Report.[8,133] The addition of these new measures resulted in five core indicators being used by ITN programmes to measure coverage:

1. The proportion of children <5 sleeping under an ITN last night
2. The proportion of the total population sleeping under a net last night
3. The proportion of household owning at least one ITN
4. The proportion of households having universal access
5. The proportion of the population with access

Each of these measures provides a different understanding of ITN ownership and use. The most common coverage definition used to measure the output and progress of ITN programmes is, "the proportion of the population sleeping under an ITN last night". This coverage measure has a very clear definition, which is easy to interpret. The coverage statistics to measure "access", (numbers 4 and 5 listed above), are the newest coverage measure included in ITN programme monitoring, and have largely replaced "the proportion of households owning at least one ITN" (number 3). "Universal access" is defined as all individuals having an ITN to sleep under within their household, calculated as one ITN two people per household. Indicator #4 (above) is the proportion of households that meet that target. Indicator #5 (above) is calculated as the proportion of the population with access to an ITN in their home, using the same definition of one ITN for two people per household. In a population where no household had more than exactly one ITN for every two people, the calculation of #5 would be simply expressed as:

$$\frac{2 \times Total\ ITNs\ in\ the\ country}{Total\ population}$$

The true calculation is more complicated, however, because excess ITNs within one households cannot cover individuals without ITNs living in other households. So, the proper calculation is:

$$\frac{\sum\left\{\left[\max_{0 \le x \le 1}\left(\frac{Household\ ITNs \times 2}{Household\ population}\right)\right] \times Household\ population\right\}}{Total\ population}$$

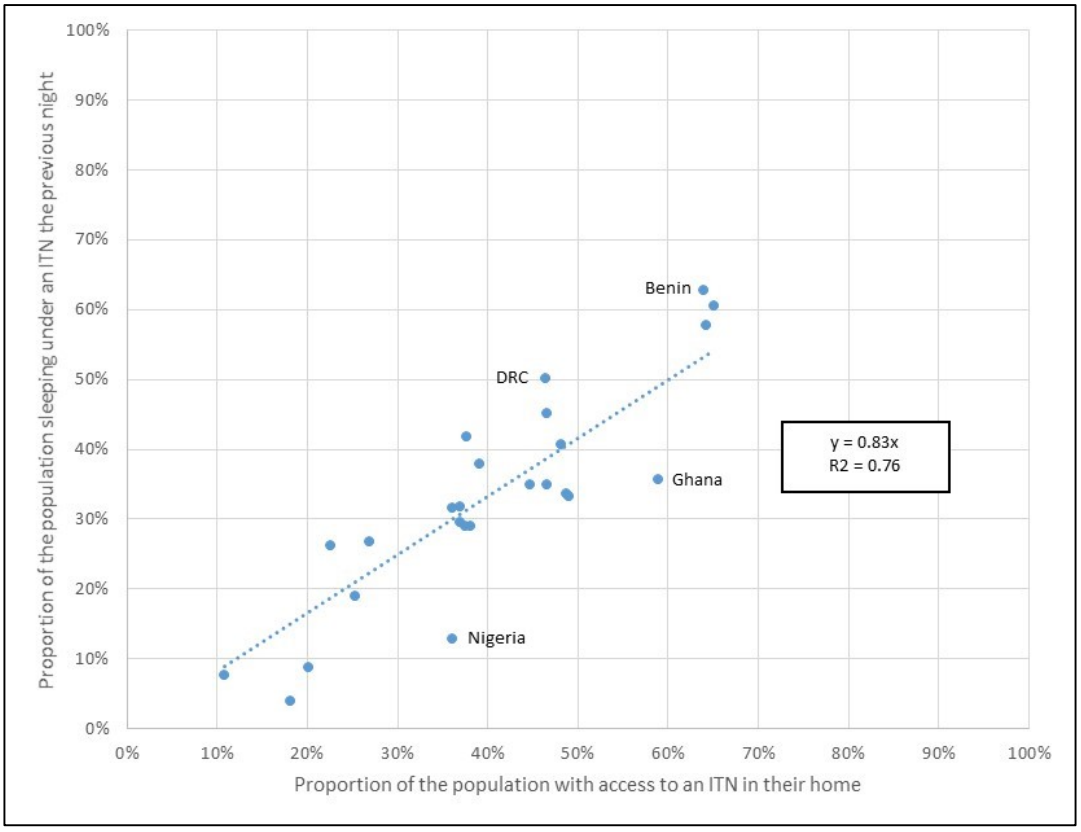
In this way, the equation limits each household to a maximum of 100% access, to understand the true number of individuals in the total population with access *within* their household.

The need for "access" measurements arose after "the proportion of households with at least one ITN" failed to predict ITN use, as overall ITN ownership, and ITN saturation within communities, rose. The "access" measurements provided more precise measures of ITN ownership, which are useful in understanding the saturation and heterogeneity that might exist across a country.

Measuring "the proportion of the population with access" is especially useful when combined with individual ITN use. By using these two measures together (ITN access and ITN use), the evaluation of ITN programmes can describe both the saturation of ITNs within a community as

well as the net use behaviour in that same community. Across countries, the two are highly correlated,[134] as can be seen in Figure 6. In multiple studies, researchers have found that the ratio of ITN access to use is approximately 80%, (also seen in Figure 6), suggesting that at both high and low ITN ownership levels, ITNs are being used effectively by about 80% of people with access to them.[125,134–136]

Figure 6: ITN Use vs Access in 25 African countries*, best-fit linear regression with intercept set to zero, analysis using DHS data



Produced using the most recent DHS datasets for each country between 2010 and 2014
* Countries included: Benin, Burkina Faso, Cameroon, Congo, Cote d'Ivoire, DRC, Gabon, Ghana, Guinea, Kenya, Liberia, Malawi, Mali, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Sierra Leone, Tanzania, Togo, Uganda, Zambia, and Zimbabwe

Challenges of ITN measurement

The large variety of coverage measures used for ITN programmes is potentially confusing. To effectively communicate research and programme monitoring finding, it is important to ensure that the specific measure being used is properly defined at all times. Because the coverage measures related to "access" are newer, there are fewer options to compare current access findings with previous research.

These ITN coverage indicators mainly rely on a single method of data collection: household surveys, conducted either as part of large national representative surveys such as the DHS, or

post-campaign surveys for monitoring. While these surveys are extremely useful in measuring ITN access and use, they cannot measure to what extent facility-based distribution programmes are consistently distributing ITNs to the target population they are designed to reach. As a result, there is a lack of indicators appropriate for programme service delivery monitoring.

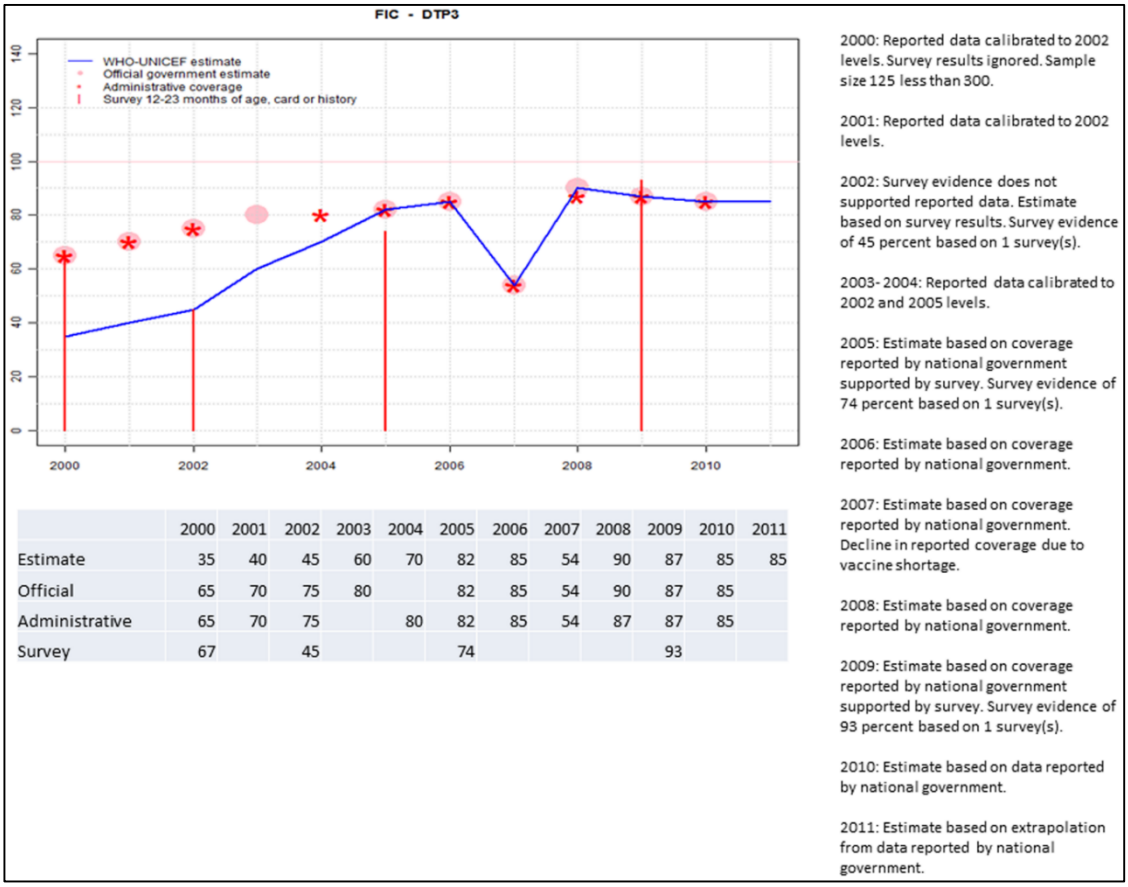
As ITN programme distribution strategies change, and in many cases diversify, (such as the inclusion of routine facility-based distribution, or school-based distribution, etc.), it may be necessary for malaria programmes to routinely incorporate process evaluations that take into account the mode of distribution, or the source of ITN within households. These indicators are not currently available routinely, limiting the types of analysis that are possible when evaluating the reach of these non-campaigns ITN distribution strategies. While some individual countries may collect facility-based data, these data are not incorporated into large scale nationally representative surveys, such as the DHS, making comparisons between countries difficult or impossible.

3.1.2. EPI programme coverage

The Expanded Programme on Immunization has a history of monitoring and surveillance as integral programme components. Early version of immunization coverage measures were used by WHO, before the inception of EPI, for example in surveillance of smallpox vaccination. In the early days of the EPI programme in the 1970s and 1980s, the WHO used the "30x7" survey approach as a rapid method to estimate coverage within 10 percentage point of the true value.[137] This method of estimating coverage involves randomly identifying 30 "clusters" of households, and selecting seven children within each cluster.[137] In total, 210 children's immunization histories are reviewed.[137] This sample size was selected to produce a set degree of precision (95% confidence limit of + or - 10%) at a coverage level of 50%.[137]

The WHO EPI program now uses multiple data sources and estimations, generally with samples much larger than 210, to produce annual coverage estimates for all EPI antigens in every country.[138,139] These sources include government estimates, administrative coverage, and survey results, as they become available.[138,139] Specific guidelines are used to identify the most plausibly accurate estimate for vaccination coverage each year. The estimation method favours administrative coverage data if survey data support the reported coverage within 10%, and selects an official WHO/UNICEF estimate equal to one of the data sources, as opposed to an average of multiple reports (Figure 7).[138,139] Even with these guidelines expert judgement and local knowledge are often necessary to evaluate conflicting sources.[138,139]

Figure 7: Explanation of WHO/UNICEF official EPI estimates, excerpt from Burton, et al, 2012[139]



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Estimate	35	40	45	60	70	82	85	54	90	87	85	85
Official	65	70	75	80		82	85	54	90	87	85	
Administrative	65	70	75		80	82	85	54	87	87	85	
Survey	67		45			74				93		

Published in Plos One, 2012, doi:10.1371/journal.pone.0047806

Figure 7 presents a fictitious country with multiple sources of coverage estimates and the WHO/UNICEF official estimates resulting from the coverage reports.[139] The table below the graph reports the WHO estimate, and coverage reports from different sources, and the column on the right describes the choice made to produce the WHO estimate.[139] For example, in 2005, the survey data of 74% came within 10% of official and administrative coverage reports, so the official number was used as the WHO/UNICEF estimate.[139] By comparison, in 2002 the survey did not support the government reported coverage, and so the survey estimate was used as the WHO estimate. [139]

The most commonly used single coverage estimate for EPI, to measure the overall success and progress of an immunization programme, is *DTP3 coverage* ("The percentage of one-year-olds

who have received three doses of the combined diphtheria, tetanus toxoid and pertussis vaccine in a given year"[116]).

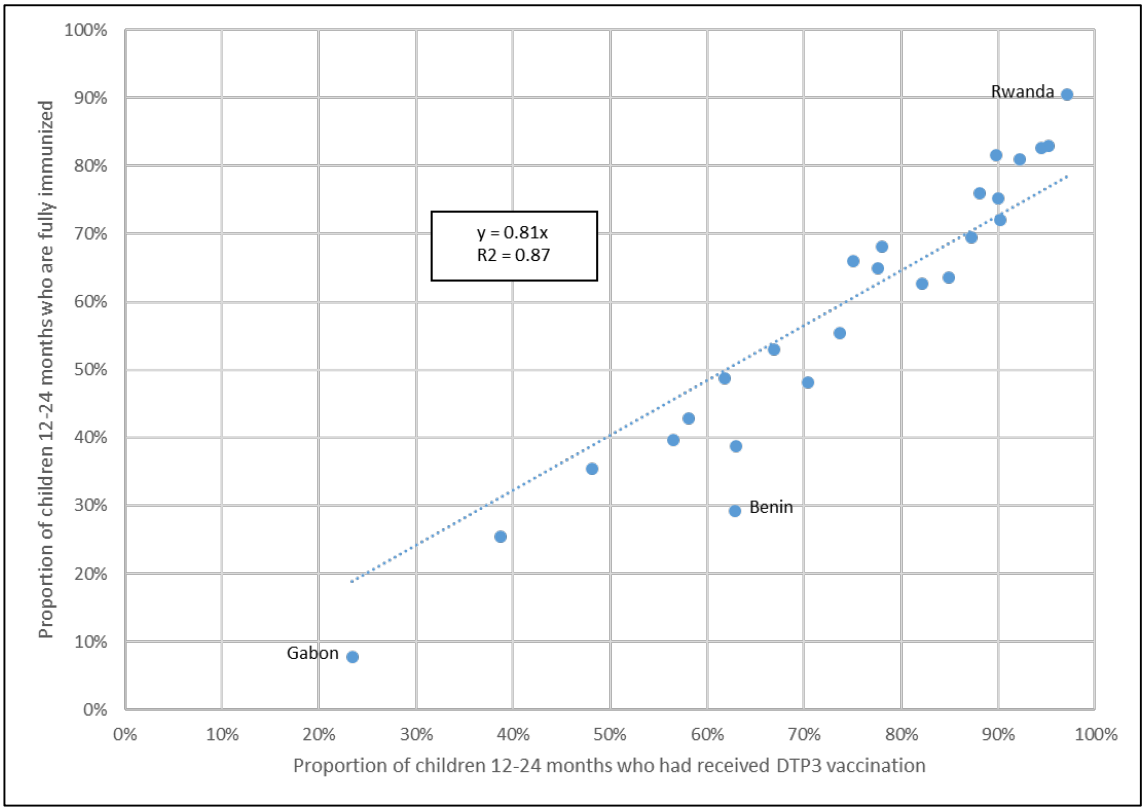
Challenges of EPI measurements

As defined, DTP3 coverage does not measure the entire recommended schedule of vaccines for a child within the first year of life. Enumerating the proportion of "fully vaccinated" children would measure a more complete picture of coverage, but this estimate faces many challenges.

The minimum standard complete vaccination schedule includes BCG, three doses of oral polio vaccine, three doses of DTP, and measles vaccine. Beyond their inclusion in the routine vaccination schedule, measles and polio vaccination are often delivered during campaigns as part of elimination efforts.[140–142] Often, vaccinations delivered during campaigns are not recorded at all. In other cases, these vaccinations are recorded with the routine vaccinations. As a result, written records and maternal recall may be subject to information bias if campaign doses of measles or polio are misclassified as routine doses.[140–142] Despite this, there is strong correlation between DTP3 coverage and full immunization coverage within countries (Figure 8).

The minimum vaccination schedule, listed above, is standard across virtually all lower and middle income countries, but since the establishment of GAVI, many more vaccinations have been added to national immunization schedules, including Pneumococcal vaccine (PCV) and rotavirus vaccine.[34,143] Additionally, some vaccines have been recommended for regional inclusion depending on disease burden, such as Yellow Fever vaccine, and Japanese encephalitis vaccine.[34,143] What constitutes a fully vaccinated child differs from one country to another and even from one region of a single country to another, depending on the vaccines offered. If the full vaccination schedule for each country were used, comparing the proportion of fully vaccinated children between countries would not maintain a standard definition, and would be a harder goal to achieve in countries with more vaccines available.

Figure 8: Comparison of DTP3 coverage with fully immunized* for 25 countries** in Africa, best-fit linear regression with intercept set to zero, analysis using DHS data



Produced using the most recent DHS datasets for each country between 2010 and 2014
* Fully immunized includes only BCG, 3 doses of DTP, 3 doses of Polio, and Measles vaccination in all countries
** Countries included: Benin, Burkina Faso, Cameroon, Congo, Cote d'Ivoire, DRC, Gabon, Ghana, Guinea, Kenya, Liberia, Malawi, Mali, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Sierra Leone, Tanzania, Togo, Uganda, Zambia, and Zimbabwe

Measuring immunization coverage (DTP3 or fully vaccinated) includes an element of timeliness, as an inherent part of the calculation. Specifically, the timeliness of vaccinations refers to how soon, or how delayed, after the point in the vaccine schedule (6 weeks, 10 weeks, 14 weeks of age, etc.), a child received a given vaccine. To ensure that child health records are available and maternal recall is fresh, immunizations are typically measured between 12 and 24 months of age (all one year olds).[30,144] If immunizations are given late, especially those later in the schedule, such as measles, and if measles is a part of the coverage measurements, lack of timeliness may be recorded as un-vaccinated.[144] Using an earlier scheduled vaccine, such as DTP3 makes the coverage target easier to meet, by comparison. However, using earlier vaccination can misrepresent vaccination coverage if interpretation is not clear. Children who are not fully vaccinated, and who may have missed later vaccine visits entirely, can be recorded as "covered" if DTP3 is used, over-representing the amount of children effectively reached by this service. It is worth mentioning that timeliness of

vaccination delivery is an important element of effective service, to minimize the period of time in which a child is at risk of infection and disease.[30,144]

The source of the data used to measure vaccination coverage can also be challenging. There are three possible data sources: 1) Facility vaccination records, 2) Child/family health booklets, and 3) Maternal recall.[139] Each of these sources presents different strengths and weaknesses. Facility vaccination records may accurately tabulate the total vaccinations given out at a facility, but are unlikely to have the denominator of total children in the community who should have been vaccinated. Child or family health booklets are small documents given to mothers to keep track of vaccinations and other routine health checks, each time the mother and child attend a health service. These booklets should include all services and vaccines a child received, but some records may be missing if the booklet was left home one day, and may be missing all together if the child is older and/or if the booklet was lost. Maternal recall has the potential to be less accurate the more children a woman has, and the older the child in question is.

3.1.3. ANC programme coverage

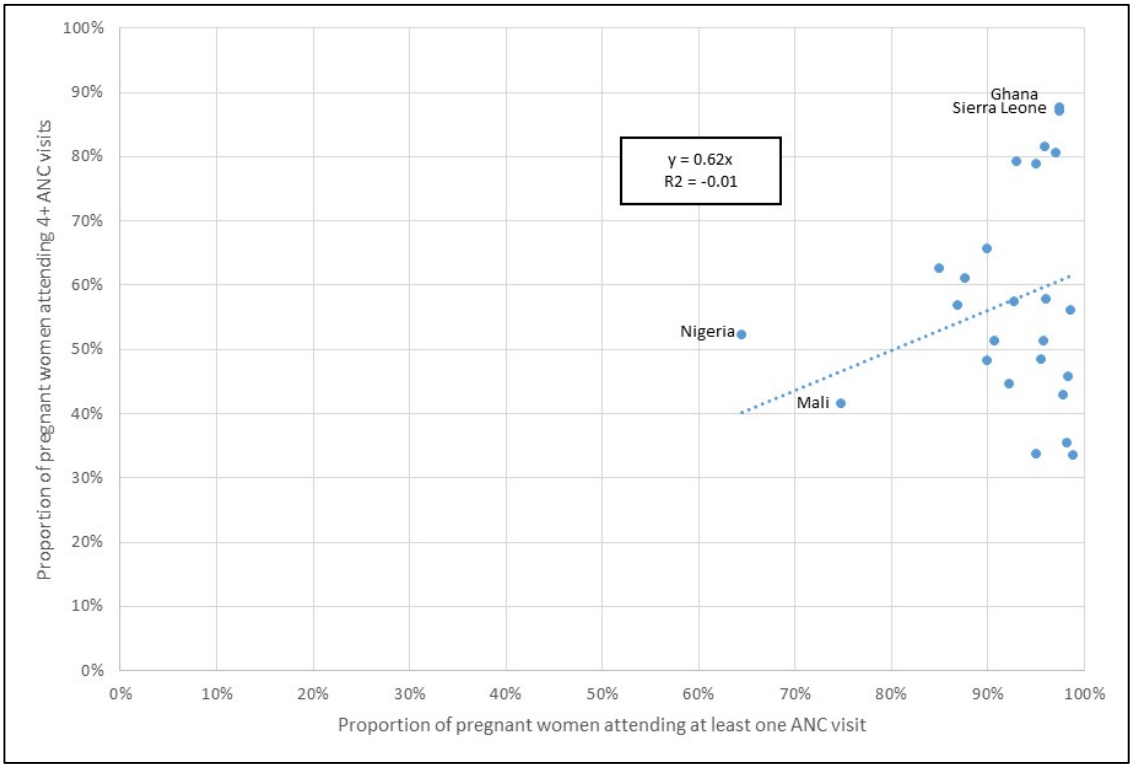
Antenatal care programmes have developed various ways of measuring the proportion of pregnant women who received pregnancy-related health care. While the official definition for ANC coverage is: "The percentage of women aged 15-49 with a live birth in a given time period that received antenatal care provided by skilled health personnel (doctors, nurses, or midwives) at least once during pregnancy,"[116] the most common calculation of ANC coverage represents a slightly different definition. In reality, the numerator is: "the number of pregnant women attended, at least once during their pregnancy, by skilled personnel for reasons related to pregnancy during a fixed period", and the denominator is: "The total number of live births during the same period."[117] As a result, the numerator is not a true subset of the denominator, especially when the time-period in question is one year, as is often the case for annual coverage estimates. (It is worth noting that this is a common feature of other such similar statistics, such as the "infant mortality rate," and as such they are often called ratios rather than rates.) Except in extreme cases, such as famine or war, the denominator in question should be a constant proportion of the population without significant variation from one year to the next. Using only live births as a denominator is also somewhat problematic. While all pregnancies, regardless of the birth outcome, should receive antenatal care, only live births are used in the denominator, due to the difficulty in accurately enumerating non-live

births, such as stillbirths and miscarriages. As a result, the amount of ANC needed within a population will be underestimated.[117]

The above-mentioned coverage indicator measures at least one ANC visit during pregnancy. It has become common to measure four or more visits as well, since the focused ANC guidelines from WHO in 2001 recommended four ANC visits for all pregnant women.[42] Unlike the ITN ownership vs use, or DTP3 vs full immunization, one ANC visit is not correlated with four or more ANC visits, especially for countries in Africa (Figure 9). Most countries have high coverage of at least one ANC visits (over 80% in the 25 countries included in Figure 9). Coverage of four or more visits is much more variable across countries, and is not predictable based on one ANC visit.

Routine service delivery data, and household survey data are both used to produce ANC coverage estimates. In most low and middle-income countries, both data sources are available to produce national ANC statistics.[117]

Figure 9: At least one compared to 4+ ANC visits in 25 African countries*, best-fit linear regression with intercept set to zero, analysed using DHS data



Produced using the most recent DHS datasets for each country between 2010 and 2014
* Countries included: Benin, Burkina Faso, Cameroon, Congo, Cote d'Ivoire, DRC, Gabon, Ghana, Guinea, Kenya, Liberia, Malawi, Mali, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Sierra Leone, Tanzania, Togo, Uganda, Zambia, and Zimbabwe

Challenges of ANC measurement

In order for ANC to be delivered effectively, there are multiple factors to consider. These include: the number of ANC visits, the timeliness of ANC visits, the quality and completeness of care, and the type of health service provider delivering the service. There are a variety of challenges associated with incorporating these factors into a coverage measure.

Most typically, ANC coverage is measured as either at least one ANC-visit or at least four ANC-visits during pregnancy. In 2001 a WHO-led randomized trial and systematic review showed that four ANC visits were needed to provide the full package of essential interventions designated as necessary during ANC.[39,42] As a result of these findings, programmes began measuring four ANC visits as proxy for both attendance and quality of ANC services. This number of visits has been considered appropriate to deliver the full antenatal care package for health women with no underlying medical condition and for normal, uncomplicated pregnancies.[37] When reviewing DHS surveys of ANC visits, the questionnaire allows for the possibility of 20-30 visits per woman per pregnancy.[145] While it is rare to find a woman in the datasets attending ANC 20-30 times, this suggests that there are some women for whom more visits are recommended and potentially necessary. The recommendation of four ANC visits was meant for uncomplicated pregnancies, for which routine care was adequate.[36,37] In November of 2016, the WHO released new ANC guidelines recommending eight, instead of four, ANC visits during pregnancy.[44] If these guidelines are used in the future, eight visits will be necessary to measure full coverage of ANC services.

Related to the number of visits, the timeliness of ANC visits is also considered a key part of effective ANC delivery, but is rarely included in ANC coverage statistics. ANC recommendations include that the first ANC visit should occur within the first trimester of pregnancy, to identify and treat underlying complications such as syphilis, malaria, and anaemia.[37,42] While extremely important, this is difficult to measure because gestational age early in pregnancy can be difficult to estimate accurately.[146,147] Timeliness and the total number of ANC visits are not independent elements since a first ANC visit early in pregnancy leaves more time for three additional visits before a woman gives birth. Timeliness is an even greater challenge when measuring ANC coverage against the new recommendation of eight visits during pregnancy.[44] If the first visit occurs after the first trimester, fitting seven more visits in will be difficult. Further, approximately 10% of babies are born before 38 weeks, many of which are considered full term, having reach 37 weeks gestation.[148] Those pregnancies delivering before 38 weeks would miss the final two ANC visits, which would mean that even if

all women followed the schedule as prescribed, 10% of pregnancies would not be covered by complete ANC due to spontaneous labour.[148]

The variation in quality and completeness of antenatal care makes the measurement of ANC programme "coverage" significantly more challenging than that for ITN or EPI delivery. The WHO has described the essential components of goal-oriented ANC, in what is referred to as *focused antenatal care*.[42] Focused antenatal care describes the specific services that should be provided at each ANC visit to ensure a minimum quality of care.[37,42] Powell-Jackson, et al, recently analysed the quality of antenatal care using DHS surveys in 46 low and middle-income countries.[149] They found that the included interventions varied by country. Comparing quality of care coverage between countries becomes challenging as a result, as the denominators of recommended services are not equivalent from country to county. It was also not possible, using the data available, to evaluate whether the interventions were provided at the correct time.[149] They also noted that the relative importance of the different interventions was not equal, so two women missing one intervention were not necessarily at the same disadvantage, in terms of care provided.[149]

3.1.4. Use of coverage measures in this project

The major benefit of common terminology and a single coverage point estimate is the ability to compare different places, different times, and different programmes with relative ease. It also allows readers to quickly understand the topic of interest without spending time digesting new definitions. Because of the commonness of the word "coverage", research may report coverage findings without adequately defining how coverage is being measured, which can lead to misrepresentation of findings.

Standardized definitions of coverage also allow researchers and policy makers to chart progress made by programmes over time, by comparing more recent coverage estimates to previous statistics. As programme goals and strategies change, however, there is often a need to update or change coverage definitions to more accurately reflect the aims of health programmes and the target of service delivery, as has been seen with both ITNs and ANC.

New terminology, by comparison, can lead to confusion and impracticality, when there are existing standardized measures available, which would be suitable. But, new definitions of coverage allow researchers to measure exactly what they intend to, without compromising the aim of research to fit old norms. New terminology also allows more rigorous measures to be added and used as programmes meet and surpass benchmarks in progress.

In this project both older standard definitions (such as at least one ITN per household) and newly added standard definitions (such as at least four ANC visits) discussed above, are used, as well as unique definitions of coverage created specifically for this research. Significant thought and consideration was given to each type of coverage measured, and the relative benefits and drawbacks that they would afford. In reference to Tanahashi's coverage definitions, both Availability Coverage (people for whom service is available) and contact coverage (people who use service) are used within this project.[111]

Each coverage statistic used in each chapter is described there, but below is a brief explanation of the different measures used in this project, for comparison.

In chapter 4, the first results chapter of this project, a new coverage metric was calculated, called an "Availability Ratio". This coverage metric calculates the number of ITNs made available through antenatal care and the expanded programme on immunization, as compared to the number of women and children attending these services.

Embedded in this new coverage terminology are assumptions about ANC and EPI coverage definitions. The denominator of the availability ratio is the number of women or children who attended ANC or EPI. In this case, the number of women with "at least one ANC visit" was used for the ANC denominator, and both DTP1 and Measles vaccination attendance were used as two possible EPI denominators, to produce more and less conservative estimates of the availability ratio. ANC numbers were reported by national malaria programmes, which may represent either national ANC attendance number or ANC numbers in targeted districts, in countries with targeted ITN distribution programmes. EPI numbers, by comparison, were extracted from the WHO EPI programme coverage statistics, and always represent national numbers. While some countries, such as Kenya, have regionally targeted ITN distribution strategies, most countries are implementing national policies. The inability to disentangle this information, however, may have created overly conservative estimations of coverage, so therefore a higher shortfall in some countries.

In chapter 7, the first chapter which analyses DHS data, a few different ITN coverage measures were used, all of which are standard ITN coverage measures used by WHO and RBM (discussed above). These include:

- the proportion of children sleeping under a net last night
- the proportion of households with at least one ITN

- the proportion of households with universal access

In several cases the household measurements (at least one ITN, and universal access) were used to stratify results, rather than as stand-alone coverage measures.

Lastly, in chapter 8, the second DHS analysis in this project, three standard coverage measures were used – one for each programme included. For EPI, *the proportion of children age 12-24 months who had received DTP3*, was used as the single coverage measure. Because this project often compares the roles of routine and campaign-based services, a coverage measure for EPI that could not be biased due to vaccination campaigns was selected. Both child health booklets and maternal recall were used to confirm vaccination. For ANC, *the proportion of women attending ANC four or more times during their most recent pregnancy* was used as the coverage measure. Four ANC visits were chosen, instead of one, to distinguish between country programme implementation and strength. As seen in Figure 9, most countries have very high coverage levels of at least one ANC visit, so using an alternative measure produced more diversity in estimates. Coverage of four ANC visits also incorporates some element of quality, though minor, as four visits are necessary to provide the minimum standard of care. For ITNs, *the proportion of children under 5 years of age sleeping under an ITN the previous night* was used as the coverage indicator. Children were included, instead of all people, to have a more direct comparison between ANC and EPI. Children under 5 were used, instead of children between 12-24 months (the common denominator for EPI) in an effort to use a common coverage definition for each programme. Only including one year olds would have been a significant departure from the routinely used ITN coverage measures.

Before the final selection of these statistics, a comparison was made of a few different options, especially for ANC and EPI, across countries (Table 8). The table identified interesting patterns in programmes alone, as well as in the three programmes within any one country. Most notably, high coverage in one programme did not visually predict coverage levels in either of the other two programmes. This independence suggests that the three programmes are managed and implemented independent of one-another.

In comparing the success, breadth and challenges of different health programmes, understanding the measures of success, and discussing these precisely is paramount. Programme coverage is a commonly used phrase and measure that is often used without careful consideration of the definition at hand. This PhD uses a number of different data sources and techniques to compare programme service delivery. As a result, coverage is discussed and measured in a variety of ways. The intention, throughout this thesis, is to define

clearly the type of coverage being measured, and to be able to compare programmes and delivery strategies competently.

Table 8: Comparison of coverage measures for ANC, EPI, and ITN use, from DHS data

Country	Year of survey	% ITN use children <5 years(95% CI)	% immunization coverage children 12-24 months) (95% CI)		% ANC coverage, most recent pregnancies occurring in the 5 years prior to the survey(95% CI)	
			DTP3 coverage	Fully immunized*	At least one visit during pregnancy	Four or more visits during pregnancy
Benin	2011	71.9% (70.6-73.3)	62.9% (60.3-65.5)	29.3% (36.8-41.8)	87.7% (86.3-89.1)	61.1% (59.4-62.8)
Burkina Faso	2010	48.5% (46.6-50.3)	89.8% (87.7-91.6)	81.6% (79.0-83.8)	95.1% (94.2-95.9)	33.7% (32.2-35.2)
Burundi	2010	45.6% (42.6-48.5)	95.2% (93.2-96.7)	83.0% (79.8-85.9)	98.9% (98.5-99.2)	33.5% (31.5-35.5)
Cameroon	2011	11.7% (10.7-12.8)	66.9% (63.0-70.5)	53.0% (49.0-56.9)	85.0% (82.9-86.9)	62.6% (60.6-64.6)
Congo	2011	31.6% (29.4-34.0)	56.5% (51.4-61.3)	39.6% (35.4-43.9)	93.0% (91.4-94.3)	79.2% (77.4-81.0)
Cote d'Ivoire	2012	38.7% (35.9-41.6)	61.8% (56.8-66.6)	48.8% (43.9-65.8)	92.2% (90.8-93.3)	44.5% (41.9-47.1)
DRC	2012	57.2% (54.6-59.7)	58.1% (54.1-62.0)	42.8% (38.9-46.9)	89.9% (88.6-91.0)	48.3% (46.0-50.6)
Gabon	2012	41.1% (38.1-44.2)	23.4% (19.0-28.4)	7.7% (5.0-11.8)	95.1% (94.1-95.9)	78.9% (76.9-80.8)
Ghana	2014	47.9% (45.4-50.4)	90.0% (86.9-92.4)	75.2% (70.3-79.6)	97.4% (96.4-98.2)	87.7% (85.8-89.4)
Guinea	2012	27.5% (25.2-29.8)	48.1% (43.0-53.3)	35.4% (30.9-40.1)	86.9% (84.5-88.9)	56.8% (54.0-59.6)
Kenya	2014	55.2% (53.5-56.8)	90.2% (88.8-91.5)	72.0% (69.8-74.0)	96.0% (95.6-96.4)	57.8% (56.5-59.0)
Liberia	2013	39.5% (36.3-42.9)	73.7% (67.6-79.0)	55.4% (49.4-61.1)	97.1% (96.4-97.8)	80.6% (78.5-82.5)
Malawi	2010	40.9% (39.4-42.4)	94.4% (92.4-96.0)	82.7% (79.7-85.4)	98.3% (98.0-98.6)	45.8% (44.5-47.0)
Mali	2012	70.6% (68.9-72.4)	63.0% (58.9-66.9)	38.8% (34.6-43.1)	74.8% (72.2-77.2)	41.6% (39.2-44.1)
Mozambique	2011	36.7% (34.7-38.7)	77.6% (74.7-80.2)	65.0% (61.6-68.2)	90.7% (89.1-92.2)	51.2% (49.2-53.2)
Namibia	2013	6.6% (5.4-7.9)	92.2% (88.8-94.6)	80.9% (76.7-84.5)	95.9% (95.0-96.7)	81.5% (79.5-83.2)
Nigeria	2013	16.7% (15.4-18.1)	38.7% (36.4-41.0)	25.5% (23.7-27.5)	64.5% (62.1-66.9)	52.2% (50.0-54.3)
Rwanda	2010	70.5% (69.0-72.0)	97.1% (95.7-98.0)	90.5% (88.3-93.4)	98.2% (97.8-98.5)	35.5% (33.8-37.2)
Senegal	2010	36.1% (33.4-38.8)	82.2% (78.7-85.3)	62.6% (58.5-66.5)	95.8% (95.1-96.5)	51.2% (49.2-53.2)
Sierra Leone	2013	51.6% (49.1-54.0)	78.0% (74.3-81.3)	68.1% (64.1-71.9)	97.5% (96.9-98.0)	87.0% (85.5-88.4)
Tanzania	2010	64.5% (62.0-67.0)	88.1% (85.4-90.3)	76.0% (73.0-78.8)	97.9% (97.2-98.5)	42.9% (40.9-44.9)
Togo	2013	44.5% (42.4-46.6)	84.9% (80.8-88.3)	63.6% (58.2-68.7%)	92.7% (91.2-94.0)	57.4% (55.2-59.6)
Uganda	2011	44.7% (42.3-47.1)	70.4% (65.6-74.8)	48.2% (42.8-53.7)	95.6% (94.7-96.4)	48.5% (46.3-50.6)
Zambia	2013	41.1% (39.3-42.8)	87.2% (85.3-89.0)	69.5% (67.2-71.7)	98.6% (98.2-98.9)	56.0% (54.5-57.6)
Zimbabwe	2010	10.4% (8.9-12.2)	75.1% (71.1-78.7)	66.0% (62.0-69.7)	89.9% (88.3-91.2)	65.7% (63.6-67.7)

* Fully immunized includes: BCG, 3 doses of DTP, 3 doses of OPV, and measles vaccination

3.2. Rapid Assessment Process

Rapid Assessment Process (RAP) is a method of rapid qualitative research. The earliest qualitative rapid assessment methods were developed to support field research on farming systems, the most common of these being the Sondeo approach.[150] Meaning "to sound out," the Sondeo approach was first described by Hildebrand in 1979.[151–153] The Sondeo approach was characterised as a method of "learning about local people's situations, experiences, problems, and perspectives directly from the people themselves".[152,153] Using key informant interviews and focus groups with local people, the Sondeo approach aimed to collect relevant data more rapidly, which could be used for analysis and report writing, necessary for farming evaluations within a single planting season.[152,153]

Building on the Sondeo approach, various Rapid Assessment and Participatory Rural Assessment methods were developed in the late 1980s and early 1990s, and were applied to several research fields including health.[150,154,155] Three broad categories of these rapid assessments exist:

- Rapid Appraisal/Rapid Assessment[151]: These assessments focus on data collected to answer narrowly defined and specific research questions. The design and analysis are conducted predominantly by individuals from outside the study population.
- Rapid Assessment Process (RAP)[151]: These assessments use open-ended questionnaires and guided interviews to identify information important to the host community and relevant to broader research questions. Research questions are identified both *a priori,* and in consultation or collaboration with local study populations.
- Rapid Ethnographic Assessments/Participatory Rural Assessments[151]: These assessments are intended to support local communities to identify and share their own experience. In these studies, outside researchers provide communities with the tools to assess themselves, but do not begin with a priori hypotheses.

The rapid assessment methods were designed with the purpose of addressing a specific problem, or evaluating a specific situation or environment, with the aim of producing data for analysis, and recommendations, in a timeframe useful to decision-makers.[151,152,155,156] The details of each approach differ, but broadly, all rapid assessment methods advocate small multi-disciplinary teams conducting semi-structured interviews over one to six weeks to gain insights into the systems and experiences of interest.[150,151,155] The "rapid" nature of these

methods sets them apart from other qualitative study designs, such as traditional ethnographic methods, which often require prolonged fieldwork.[151] If qualitative study methods range from the most structured surveys with closed questions and structured response categories, to the least structured in-depth qualitative research without any directed questions, rapid assessment methods fall in the middle. These rapid techniques all aim to gain information difficult to obtain from more formal close question survey structures (such as information related to opinions, experiences, and intentions), in a relatively short period of time, as compared to in-depth qualitative studies.[153]

While rapid qualitative methods have been developed for use in any discipline, there have been significant developments for the use of these methods in public health research.[157–162] Specifically, rapid assessments have been identified as useful in assessing disease control programmes.[162] This includes, but is not limited to: preparation of field sites, exploratory research, supplementary research in conjunction with quantitative methods, programme evaluation, and monitoring health systems research.[162] Most notably, research into diarrhoeal disease prevention and the use of oral rehydration salts (ORS) has utilized these rapid assessment methods to inform tailored interventions with limited time and budgets.[162–164]

3.2.1. RAP Study Characteristics

RAP is not a suitable method for all research questions. While early writings on this method suggested its practical use in quantitative endeavours, such as quickly calculating disease prevalence estimates or improved estimates of causes of death,[155] more recent thinking generally favours the use of an RAP for qualitative assessments where numbers and percentages are not the main objective.[151] There are rapid methods, such as the Rapid Epidemiological Assessments used by WHO EPI for programme evaluation, such as the 30x7 sampling technique, which rapidly produce numerical estimates.[137,154] The field of RAP, however, is distinguished from these other rapid techniques as a mainly qualitative research method.

Early advocates of the RAP note that an important goal standardizing the method of RAP was to "refute the notion that rapid assessment generates inaccurate data or just summarizes impressions".[155] As a result, RAP methods aim for the highest possible accuracy, in representing both objective truths and a breadth of experiences.[155] This is especially valuable when RAP is integrated into larger research projects with both qualitative and quantitative objectives. In order to achieve this accuracy, an effective RAP is defined as containing three general principles[165]:

1) A systems approach[165]

2) Triangulation of data collection[165]

3) An iterative data collection process[165]

A "systems approach" can be defined as a process through which the researchers gain information and insights from individuals with differing involvement and stake in the research question at hand.[165] The "system" is defined differently depending upon the research question. Broadly, the system consists of the coordinated elements necessary to provide the service or accomplish the task central to the research question.[165] It might be defined as a community (including schools, health centres, religious centres, etc.), but often in public health research, the system is defined as the health system within which the health intervention or programme of interest exists.[154,162,165] During the planning phase of an RAP, the system might be defined very broadly, but will ultimately be scaled down to include those elements most important to the research question. The RAP team is responsible for identifying the parts of the system deemed most essential to the specific situation being examined. Individuals from these essential elements of the system are interviewed. The systems approach strengthens the assessment by ensuring that different perspectives relevant to different levels of the health system, from policy makers to implementers, etc. are being considered.[157]

In the context of RAP, "triangulation" can be defined as the corroboration of findings by comparing multiple interviews, and written reports, in order to investigate discrepancies, to distinguish between the truth and varying perceptions of the truth.[154] This is an important feature of an RAP as a means of data validation, both internally to the relevant sub-section of the health system, and externally within the health system as a whole.[155,157] An example of this would be reviewing drug stock level records, after health facility staff have reported consistent stock-outs; or, reviewing vaccination policies after health workers explain how they understand their roles and responsibilities. These findings provide information about the objective realities, peoples perceived experiences, and how they differ. The process of triangulation sets RAP apart from other qualitative methods, as it identifies both objective realities and personal opinion and experience as separate to those realities.

An "iterative process" can be broadly defined as "a process by which replications of a cycle produce results that approximate the desired results more and more".[151] In a RAP, the iterative process, is applied to both the interviews and the subsequent analysis of the collected

data. The iterative process, for conducting interviews, is one in which the interview guides are continuously updated, to include areas of interest identified in previous interviews, which will be included in subsequent interviews. [151,165] The intention of the iterative process is to allow the individuals or groups being interviewed to direct conversations towards areas of particular interest or concern to them, as related to the topic at hand.[151] This is essential for identifying themes that may be outside the researchers' knowledge or expectations at the beginning of the rapid assessment process.[151] It is an essential part of a rapid assessment, as well as a key feature of broader ethnographic methods. Because of the rapid nature of the method, however, the researchers are limited in their ability to follow tangential ideas which arise as part of the iterative process (common in ethnographic methods).[154] This can be seen as both a strength and a weakness of the RAP, limiting the investigation of peripheral topics, but alternatively maintaining a focus on the research questions originally identified. The iterative process, as it applies to analysis, is the identification and re-identification of themes that arise with each additional review of the data collected. In this way, both *a priori* themes as well as newly identified themes can be thoroughly explored.

Another key feature of rapid assessments, integral to an RAP, is the team-based approach. The interviews in an RAP are conducted by teams of at least two people who are all engaged in the interview process, to provide follow-up questions, and to illicit further discussions on a broad range of topics.[151,165] A least one member of the team should be viewed as an insider to the system, to provide a local perspective within the interviews.[151,165] The team, as a whole, should be made up of individuals with diverse rolls and perspectives, in relation to the research questions at hand.[151] During the interview process, team members can follow different lines of questioning that they identify as relevant, based on their differing experiences and viewpoints, which supports the iterative interview process.[151]

The findings of an RAP are meant to be available for both research and programme utilization. The information gathered can be used to generate new health programmes, improve health programme planning, and implement and/or evaluate existing health services.[155] The rapid nature of RAP ensures that results are available to decision makers and programme implementers at a time when they are most relevant for programme improvement.[151]

3.2.2. Use of RAP in this project

A Rapid Assessment Process (RAP) was used for the qualitative evaluation of the routine facility-based distribution of LLINs in four countries, leading to the results presented in chapters 5 and 6 of this project. The main objective of this RAP was to identify strengths and

weaknesses of ITN distribution through routine ANC and EPI services in four countries in Africa. The distribution of ITNs via ANC and EPI is a relatively new routine health programme across Africa. As a result, there has been little sharing of institutional knowledge about the barriers and bottlenecks that may exist in implementing this programme routinely. The use of an RAP provided a research method through which a broad range of health systems structures could be explored as they relate to facility-based ITN distribution. This research was undertaken as routine operational research in collaboration with the National Malaria Control Programme (NMCP) in each country. It was implemented with the joint goals of providing timely feedback to programme managers and funders, as well as collecting qualitative data for further analysis.

To ensure that key elements of the health system were addressed, the WHO "6 building blocks to health system strengthening": Service Delivery; Health Workforce; Information; Medical Products, Vaccines, and Technology; Financing; and Leadership and Governance, were used to structure the direction of the interviews.[166] A sample interview guide can be seen in Appendix B. Using these key structures of the health system as a template for semi-structured interviews allowed the team to identify concerns across the full spectrum of the health system, without the need for an *a priori* hypothesis of specific potential barriers and bottlenecks.

The preliminary interview guide was reviewed by the funding and collaborating agencies: USAID, PMI, and VectorWorks, to get a donor perspective. Before the interviews began in each country, the guides were also discussed and reviewed with the director and/or deputy director of the national malaria control programme to incorporate additions or adjust language, as needed, relevant to each country context.

The research team consisted of two main investigators. The lead investigator (myself) and the co-investigator (Yves Cyaka, a Rwandese national living in Switzerland, working as a consultant for Tropical Health, with extensive experience supporting country Global Fund grant applications for malaria programming). These two investigators travelled to all four countries together, and led and participated jointly in all the interviews. In each country, the lead and co-investigator were joined by ministry of health officials, and/or partner organizations staff, who were briefed on the evaluation process, and who joined the interview process to provide the "insider perspective".

The interviews were conducted in groups ranging from just one respondent to small groups of five individuals. Individuals at the national, regional and facility levels were purposively selected as key informants, due to their detailed knowledge of routine facility-based ITN

distribution. At the national level, key informants from national logistics management, as well as staff from partner organizations supporting routine ITN distribution, were also invited to be interviewed. At the facility level, staff responsible for service delivery (often the same staff for both ANC and EPI) were interviewed about the delivery of these programmes. All participants were given information about the evaluation, and given the opportunity to ask questions, after which a consent form was signed with multiple opt-in participation choices (Appendix C). The interviews were conducted using the iterative process (described above) on the basis of the semi-structured interview guides. The intention was to identify and probe into areas that may have had local or cultural significance beyond the knowledge base of the lead and co-investigators. All interviews were conducted in English or French, and recorded. The ministry of health officials and partner organization staff were also instrumental in identifying programme documents and policies used for further knowledge gathering and triangulation. The guidelines for service delivery for each programme (Malaria, ANC and EPI) were collected in each country. The service delivery statistics, quantification results, and other supporting document for service delivery from these programmes, were also collected and reviewed with specific detail paid to comparisons with service delivery reports discussed at the facility level. At facilities, service delivery records and health facility score cards were reviewed and photographed (removing personal identifiers) to corroborate other findings from interviews and national programme documents.

The analysis focused on the development, interpretation and implementation of the national policies for integrated ITN distribution. As such, the end user perspective was not included in this analysis. Instead, only the staff responsible for these aspects of the policy were included in the interview process. The interviews were transcribed, and in the case of the French interviews translated, by professional transcribers from each country in which the evaluation was conducted. This ensured idioms and local vernacular were more easily translated appropriately.

The analysis was conducted using Nvivo, a qualitative analysis software which allows findings and quotations to be categorised by thematic areas. Using the WHO building blocks for health systems strengthening as the *a priori* thematic areas of concentration, the interviews were first coded to look for specific quotations related to those thematic areas. As tangential themes emerged, the interviews were reviewed again to look for new quotations related to these new themes. Quotations specific to each programme (ITN, EPI and ANC) were also coded, independent of the health systems themes, as well as quotations related to other health

services (drugs, vaccines, etc.). Programme documents and reports were also coded into themes, in support or contradiction of quotations identified by health service staff.

Throughout the process, from designing the interview guides to the analysis, a reflexive approach was used[d]. The lead investigator has had more experience in EPI programmes than in ANC programmes, and so was conscious of potential biases as a result of previous experiences. Effort was made to evaluate EPI and ANC programme success independent of any pre-conceived notions of programme strengths and weaknesses.

The RAP method allowed for the identification of unique challenges to the routine distribution of ITNs, as compared to other routine services, and differences in ANC and EPI as platforms for other routine service delivery. The results of this analysis led to the identification of barriers related to 1) service delivery operations, and 2) the service delivery platforms (ANC and EPI). These findings are described in detail in chapters 5 and 6.

[d] Reflexivity[254] is a process through which the researcher(s) actively recognize their own experiences, biases and perceptions that will influence the researcher's judgement of findings. Reflexivity is an important element of qualitative research. While it is most often discussed as part of the "grounded theory" methods, is can be applied to RAP as well. The results of the RAP used in this project were less subjective than in-depth qualitative methods, such as ethnographic studies, but the reflexive process was still applied in an effort to be self-aware.

3.3. DHS Analysis

Demographic and Health Surveys (DHS) are comparable, cross-sectional, nationally representative household surveys, conducted in more than 85 countries worldwide.[167] The DHS programme began in 1984 as a five-year project to update and expand on the knowledge and data gathered from the World Fertility Surveys (WFS).[168] The WFS was jointly funded by the United States Agency for International Development (USAID) and the United National Population Fund (UNFPA), and was headed by the international Statistical Institute, based in the Hague.[169] The WFS ran from 1972 to 1984, with the aim of producing comparative research on the topics of fertility, mortality, and to a lesser extent child health, especially in developing countries. During the twelve years, WFS implemented 41 nationally representative country surveys, and provided technical support for a further 17 European national surveys.[169]

With assistance from the Population Council as a major sub-contract, the original DHS programme ran from 1984 to 1989, and collected health and demographic information on 30 developing countries, from 35 nationally representative surveys.[167] Thanks to the great success of the original project, the DHS was expanded to become a standard project funded primarily by USAID with support from other international donors and host countries.[168]

The original questionnaire was developed over two years, and included questions asked of women aged 15 to 49 years, in eight core sections[167]:

1. Background characteristics – household size, age, education, religion, ethnicity, household characteristics (such as type of toilet and roof), etc.
2. Reproduction – Fertility, birth history, pregnancy status, and pregnancy care if currently pregnant, etc.
3. Contraception – knowledge of methods, ever used and current use of methods, source of contraception and information, etc.
4. Births in the last 5 years – prenatal care, assisted delivery, breast feeding, child immunization, childhood diarrhoea, etc.
5. Marriage – marital status, sexual activity, etc.
6. Fertility preferences – interest in children, ideal birth timing, and desired household size, etc.
7. Education and employment – women and husbands' background, education, and employment, etc.
8. Anthropometric measurements – weight and length of children 0 to 3 years of age.

One of the key ways in which the DHS differed from the WFS was the inclusion and expansion of questions on child health, only briefly covered in the WFS.[167] THE DHS also expanded on the social and economic standing of women, including questions on education, religion, and employment that had not been collected in the WFS.[167] The original survey design was structured to be nationally representative so it could be used to make policy and implementation decisions.[169] The questionnaire was standardized for all countries to ensure comparability between countries, and regionally.[169]

After the original five-year DHS programme, the DHS was renewed for two additional five-year phases (DHS I: 1984-1990; DHS II: 1988-1993; DHS III: 1992-1998).[170] In 1997, the DHS became a permanent part of the multi-project programme called MEASURE (Monitoring and Evaluation to Assess and Use Results) to support data collection and use for national policy decision making.[170]

3.3.1. Surveys and Data collection

Since its inception in 1984, the DHS surveys have undergone a series of revisions and have expanded to include a broader collection of health and demographic topics beyond fertility.[171] The survey now also includes a men's questionnaire. While the DHS was designed to be standardized across all countries, optional modules have been added for regionally specific health issues.[171] These modules have become an important part of DHS datasets, and include: human immunodeficiency virus (HIV) and the acquired immune deficiency syndrome (AIDS), Malaria, and domestic violence.[171] The collection of biomarkers has supported the analysis of the prevalence of conditions like anaemia, HIV infection, and malaria parasitemia.[171]

Each year, with support from the MEASURE DHS project and the use of standardized survey manuals, DHS surveys are conducted in countries throughout the world by local institutions (most commonly national statistics offices). As of 2017, over 300 surveys have been conducted in 91 countries, worldwide, with many countries having had at least two surveys conducted.[169] Each country implements the standard DHS survey, which is made up of a household questionnaire, a women's questionnaire and a men's questionnaire. Additional questions of national relevance can be added to these questionnaires, and full modules on interest topics (such as HIV and Malaria) can be added in relevant countries.

The sampling design for each DHS uses a multi-stage cluster strategy, producing a dataset which is statistically robust at the national and regional level, and at the sub-regional or district level in some cases.[145] The sampling design routinely over-samples certain areas of the country

during data collection. This is corrected in the weights given to each data-entry in the resulting dataset, and can be accounted for in data analysis. Each DHS survey includes 5,000 to 30,000 households, depending on the size of the country and the number of sub-regional areas include in the sampling design.[145] In each selected household, all women between the ages of 15 and 49 are interviewed using the household and women's questionnaire. A further subset of men are interviewed with the men's questionnaire.

The household questionnaire collects information on household characteristics and on all individuals living in the household. Household characteristics include: rural or urban location; type of house construction, such as tin or thatch roof; type of toilet facilities; type of water and distance to water source; and ownership of common household goods, such as bicycles and televisions, etc.[145,170] For each individual in the household, the DHS collects basic information on age, gender, place of residence, marital status, and education level.[145] The women's questionnaire includes detailed questions on women and children's health, fertility and family structures, marriage, illnesses, etc.[145]

3.3.2. Dataset Recodes

After the DHS has been completed in a country, the data collected in the questionnaires are cleaned and collated. The DHS programme releases anonymized dataset recodes, which are collections of DHS data from a single country, with a collection of relevant information, and a specific unit of measurement. In total 7 recodes are available for each DHS:

1. Births' Recode[145] – a complete record of all births, with more detail for those occurring in the last five years. This file is often used for fertility and mortality rate calculations. The unit of measure is each birth.
2. Children's Recode[145] – a detailed dataset of all births within the last five years, including immunizations, illnesses, feeding practice, antenatal care, etc. The unit of analysis is children born in the last 5 years (0-59 months).
3. Couple's Recode[145] – a dataset linking two individuals identified as partners, which includes the relevant individual data from the women's and men's questionnaires. The unit of measure is a "couple," both of whom were interviewed.
4. Male Recode[145] – a dataset including the information collected from the men's questionnaire. The unit of measure is a man, and includes one entry for every eligible man from the household schedule, with detailed information for the subset interviewed.

5. Individual Recode[145] – a dataset of the women interviewed, including all of the women's questionnaire data, plus some household data. The unit of measure is a woman, and includes all eligible women from the household schedule.
6. Household Member Recode[145] – a dataset including all members of a household, with descriptive individual data, such a age, sex, and education. The unit of measure is a household member from the household schedule.
7. Household Recode[145] – a dataset including all household individuals and a large collection of household variables, such as wealth, asset ownership, and distance to water. It includes all individuals, with basic information (age and sex) but no individual information. The unit of measure is the household.

Many variables of interest are found in more than one recode. As a result, datasets can be combined and matched on these repeated variables, to produce datasets containing more information than is found in any one standard recode. Within these recodes, some new variables are presented, representing the compilation of data collected during the survey, such as number of household members as the compilation of all the persons listed in each household.

Wealth Index

One important variable produced for the dataset recodes is the household wealth index. The wealth index is produced by combining information about household characteristics collected in the household questionnaire related to the ownership of selected assets (sanitation facilities, roof materials and household construction, radios, bicycles, televisions, land and livestock, water sources, etc.).[172] This is used, instead of a simple measure of income, due to the difficulty in accurately estimating individual or household income. This is especially true in rural, and agrarian areas, and in countries without a formal income tax.[173] Instead, using principal components analysis, household assets are combined, and each household is given a wealth score which places it on a linear scale ranked against other households.[172,173] The result is a composite measure of each household's cumulative standard of living.[172] The process ranks all households against each other; the resulting score is then applied to all individuals within each household, and then the population is split into five ranked groups.[173] The value presented in the DHS recodes assigns each individual to one of five ranked household wealth quintiles, representing the relative wealth of all individuals, as compared to the rest of the country.

Weights

In the survey, certain geographic areas are often over-sampled, to reduce the sample variability in some sub-groups.[174] To account for this in analysis, each entry, in each dataset recode is given a weight.[174] These sampling weights are used in the analysis of the data, and adjust for the differences in the probability that a household or individual would be selected for interview, as a result of the sampling design. By applying these weights, all the available information can be used, but the resulting calculations give each individual, or subgroup, the proper proportional representation within the population. The DHS recodes provide both household and individual sampling weights, depending on which recode file is used.

3.3.3. Malaria Module

Since 2000, the malaria module for the DHS survey has been implemented in most sub-Saharan African countries.[175] This module collects information on ITN ownership and use, IRS, the occurrence and treatment of fevers in children, and iPTp for pregnant women. [175] Biomarker testing for anaemia and parasitemia are also included for a subset of the population. [175] The majority of the results of the malaria module appear in the household recode, including the number and type of mosquito nets owned and used by the household members.[175]

3.3.4. Strengths and Limitations of DHS

The greatest strength of the DHS is that each survey uses a multi-staged cluster design, and probabilistic sampling, to ensure that the resulting datasets are nationally representative, and can be analysed to the sub-regional level.[168] This design allows subsequent analyses to distinguish between population-level, and individual-level characteristic that influence the distribution of health outcomes. The DHS generally has a response rate above 90%, increasing the reliability and accuracy of the resulting analyses.[168] Because the same questionnaire is used for the core DHS survey across countries and years, results from one country DHS can be compared to previous DHS years in that country and to other DHS countries.

There are some important limitations to the DHS, as well. The DHS survey is not designed to be evaluated temporally.[168] While one DHS survey can be compared to previous surveys, the DHS is not designed to be analysed by month or season.[174] This precludes any analysis to estimate the seasonality of disease, many of which have seasonal components (such as malaria and diarrhoea). Similarly, the DHS surveys are conducted in each country independently, so the implementation dates from country to country vary by years at a time, making comparisons in large multi-country geographical regions less precise.[168] Most of the disease

information included in the DHS is collected via self-reporting and proxy-recall, rather than medical records or biomarker data (with some notable exceptions of height, weight, anaemia and parasitemia).[168] As a result, the information collected may be subject to recall bias.

The DHS also, does not include any information on ITN distribution channels, or national policies. As a result, any analysis of ITN ownership and use must use information from outside sources if the type of distribution or policy is in question. The wealth index is a useful measure that has been standardized and validated across surveys. There are a few limitations of the wealth index, however. Wealth information is reported in quintiles, but the individual wealth ranking is not reported on a continuous scale. The wealth index also assumes equal wealth for all individuals within one household, which may not be true for all households.

3.3.5. Analysis in this project

The DHS datasets were used to produce the results presented in chapters 7 and 8 of this project. Countries were included in the analysis if they were in sub-Saharan Africa, if they had conducted a standard DHS survey between 2010 and 2014 (the most recent survey year available at the time), and if they had included detailed questions about the type of mosquito nets owned and used by individuals as part of the malaria module. In total, 25 countries were included in the analysis (Table 9).

The household recode and the children's recode were used in this analysis. The household recode included information on socioeconomic status, wealth quintile, ITN ownership and ITN use. The children's recode included information on antenatal care and immunization status. To combine them, the household recode was reshaped from "wide" (where the unit of measure was one household with each individual in the household listed as variables) to "long" (where each individual is a separate unit of measure). This resulted in the same data restructured into a dataset with individual household members as the unit of measure instead of households. This reshaped dataset was then merged with the children's dataset, matching individual children in the household dataset to children in the children's recode. All other household members were dropped in the reshape process. The resulting dataset included children as the unit of measure, and had extended household information available for each child, including maternal ANC information, and ITN use.

The analysis stratified countries using non-DHS information about national distribution policies, obtained from the WHO Malaria Control Programme (described in chapter 4). This data source identified ANC- and EPI-based ITN distribution policies, but did not differentiate

between national and sub-national distribution. As a result, it was assumed that all distribution policies were national. The analysis did not account for campaign distribution of ITNs. Campaign information was not systematically available for all countries included in the analysis, and so the impact of campaigns on ITN use in children under 5 could not be accounted for in this analysis.

Each analysis of interest was calculated for each country individually, using the DHS weights to account for the survey structure. For the multi-country analyses, in which country data were pooled, the countries were weighted equally, to produce a result which represented an average country. Because the analyses conducted aimed to answer national policy questions, it was decided that an analysis which produced results typical of an "average nation" with the given policy was useful for policy makers. To produce weights by which each country was weighted equally, all the weights of a given country were divided by the total number of observations for that country, so that the cumulative sum of the weights for any country equalled one. In this manner, the internal weights for each country were maintained, and the whole of the country was up-weighted or down-weighted proportionally, in relation to all the other countries included in the analysis.

Table 9: Countries included in DHS analysis

Region	Country	DHS year	Total households in survey	Total children in survey (0-59 months of age)
West	Benin	2011	17,422	12,679
	Burkina Faso	2010	14,424	13,716
	Burundi	2010	8,596	7,231
	Cote d'Ivoire	2012	9,686	7,093
	Ghana	2014	11,835	5,595
	Guinea	2012	7,109	6,424
	Liberia	2013	9,333	7,058
	Mali	2012	10,105	9,582
	Nigeria	2013	38,522	28,596
	Senegal	2010	7,902	11,633
	Sierra Leone	2013	12,629	10,618
	Togo	2013	9,549	6,535
Central	Cameroon	2011	14,214	10,734
	Congo	2011	11,632	8,857
	DRC	2012	18,171	17,228
	Gabon	2012	9,755	5,747
East	Kenya	2014	36,430	20,093
	Malawi	2010	24,825	18,360
	Mozambique	2011	13,919	10,291
	Rwanda	2010	12,540	8,484
	Tanzania	2010	10,300	7,526
	Uganda	2011	9,033	7,355
	Zambia	2013	15,920	12,714
	Zimbabwe	2010	10,828	5,203
Southern	Namibia	2013	9,849	4,818

An alternative weighting structure, which was not selected for this analysis, would be to weight each country by its population size to produce the "average individual". An analysis weighted by population size would give the most weight to the countries with the largest population; so Nigeria, DRC and Kenya, for example, would significantly overpower smaller countries, like Togo, Liberia and Gabon, in the results. This weighting choice, and its impact on the results of the analyses in this project, is discussed further in the discussion section of chapter 7.

The analysis was conducted in the statistical programme Stata 13 and 14, using the built-in survey commands (svy and svyset) to account for the sampling structure and weights in all analysis.

3.4. Measuring Equity

Equity is an important metric in measuring the social determinants of health. The WHO defines *equity* as "the absence of avoidable or remediable differences among groups of people, whether those groups are defined socially, economically, demographically, or geographically".[176] Applied to health, inequities are the avoidable differences in health that can be seen between different groups of people, related to social and economic differences which determine both the risk of illness and the ability to prevent or treat illnesses.[176] It is important to highlight the distinction between *inequality* and *inequity*. While inequalities in health are defined as differences due to personal choices (high risk recreational activities resulting in loss of life or broken bones), genetics, or age (the decrease in good health over time with age), etc., health inequities are defined as differences in health and access to health services which are deemed to be unfair, unethical or unjust.[176–178]

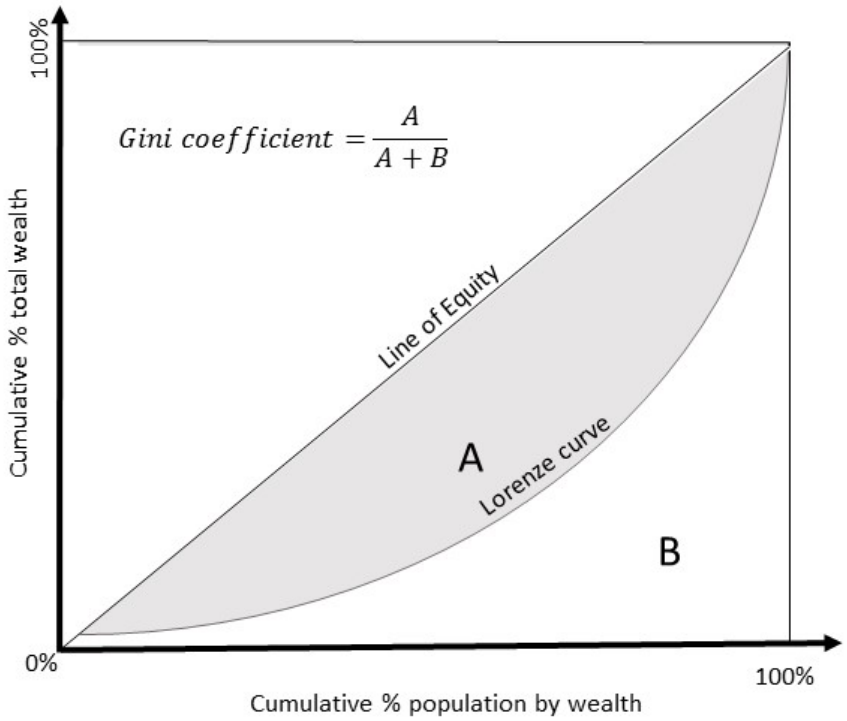
Reducing health inequity is important because health has been defined by the UN as a fundamental human right.[179] Inequities in health are particularly important because they can lead to further inequities in the ability to fully live life and achieve economic, social, and political independence and power.[176] Health inequities have resulted in the ill-health or lack of progress in health improvements for poor and marginalized communities, as compared to their wealthy and non-marginalized counterparts.[180] For example, infant and maternal mortality rates are higher, on average, for children born in developing countries, as compared to those born in high income countries.[181] On a national level in low-income countries, children from the poorest 20% of households are twice as likely to die before their fifth birthday as children from the wealthiest 20% of households.[181] Large scale projects, like the Millennium Development Goals, have focused on decreasing these types of inequity, and achieving a minimum standard of health and wellbeing regardless of social or economic status.[182,183]

In order to provide effective equitable service distribution, equities or inequities must first be measured. Efforts to quantify inequities have relied on the calculation of ranges, risk ratios and odds ratios to compare health outcomes between different social groups, by wealth, or other socio-economic measures.[184] Another method for measuring health inequities is by concentration curves, and summary measures known as "concentration indices". Based on the measurements of economic inequalities, concentration indices aim to quantify to what extent health, or ill health, is concentrated in certain subsets of the population, based on some ranking of wealth or socio-economic status.[184]

3.4.1. Concentration Indices

The first concentration index was developed based on the Gini coefficient. To calculate a Gini coefficient, a Lorenz curve is used. A Lorenz curve is the graphical representation of the cumulative wealth within a population, plotted against the cumulative population, ranked by wealth (Figure 10)[184] An important feature of a Lorenz Curve is that the population on the X-axis is ranked by the same variable that is measured on the Y-axis (in most cases wealth). On the x-axis the cumulative population is plotted, ranked from poorest to wealthiest. On the Y-axis: the cumulative proportion of wealth is plotted from 0% to 100%.[184] A perfectly equitable distribution of wealth within the population will result in a 45-degree angle line. A curve below this line will illustrate the extent to which a society has a pro-rich distribution of wealth. The Gini coefficient is the summary measure of a Lorenz curve. It is calculated as the area between the line of equity and the curve, as a proportion of the total area below the line of equity, which ranges between 0 and 1 (Figure 10). A Gini coefficient of 1, for example, would be a situation in which the wealthiest person in a population owned 100% of the wealth in that population.

Figure 10: Example Lorenze curve



In measuring health inequities, health economists have modified Lorenz curves to produce pseudo-Lorenz curves, ("pseudo" because they do not require that the population be ranked by the variable measured on the Y-axis). These pseudo-Lorenz curves are used to compare a cumulative proportion of some health measure, such as vaccination coverage or heart disease, against a cumulative proportion of the population, ranked by some other measure associated with inequity, such as wealth or socio-economic status.[184] This type of adaptation resulted in the development of a concentration index for health: C(h).[185,186] Unlike the Gini coefficient, a C(h) ranges from -1 to 1, with -1 representing the most pro-poor distribution of health resources[e], and 1 representing the most pro-rich.

As currently defined in health economics, a concentration index should use an unbounded, continuous scale variable for both wealth and health (such as income for wealth, and age or height for health). This is rarely available in measures of health, which are often categorical (such as BMI categories of underweight, normal or overweight); or binary (eg. vaccinated or unvaccinated).[185,186] Binary health measures often result in a bounded population measure; for example vaccination coverage in a population is bounded between 0% and 100%. When the concentration index is applied to bounded health measures, the bounds of the index may not be -1 to 1, seen in Figure 11.[185] In Figure 11, Wagstaff showed that as the level of coverage increases for a given bounded health measure (coverage of vaccination or ITN use, for example), the range of possible values of the concentration index narrows, so that in a population with 50% coverage, the range of the C(h) is between -0.5 and 0.5.

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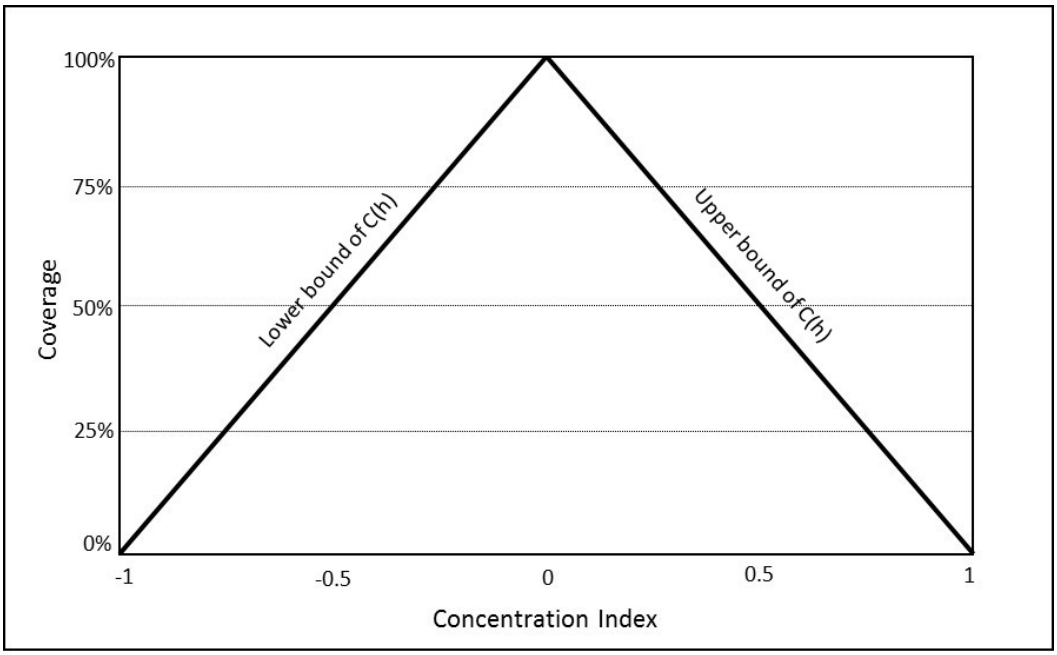
[e] In the context of concentration indices, the term "health" is used, not "health resource" in the health economics literature. In the literature, the term "health" is very broadly used to identify any indicator used to measure a health programme. This could be: the use of ITNs, vaccinations, infant mortality, etc. While many of these are not an actual measure of "health", the term is used broadly to discuss the mathematical theories for these indices when they are applied to health programmes. In this section, "health resource" is used where possible, to relate to the topics of this project (vaccines, ITNs and ANC visits). For clarity, examples such as these are often given.

The coverage of the health measure is referred to as the "mean" by health economists, as a generic term applied to any measurement. In this chapter the term "coverage" is used to maintain consistency with the rest of this project. In the health economics literature, "mean" is used.

Figure 11: The bounds on the value of the concentration index for binary variables



Adapted from a figure published in Health Economics, DOI: 10.1002/hec.953
* The solid diagonal lines represent the upper and lower bounds of the concentration index. As the mean (coverage) increases, the range of possible concentration index values narrows.

With this shortcoming in mind, in the early 2000s the health economists Wagstaff and Erreygers both created separate concentration indices for measuring health inequity, especially with bounded and binary health variables; the Wagstaff concentration index: W(h) and the Erreygers concentration index: E(h).[184,185] The mathematical equations for C(h), W(h) and E(h) can be seen in Appendix D. These new concentration indices are referred to as "corrected" because they specifically address the problem of the bounds of the C(h) when applied to bounded variables; as a result the two new concentration indices are not limited by the upper and lower bounds described in Figure 11.

The development of these two metrics has resulted in extensive discussion and debate about the principles and theories of measuring health inequity.[180,185–192] Both W(h) and E(h) can be used effectively to measure health inequity, but differ in terms of key conceptual ideas. These factors drove the creation of W(h) and E(h), and were considered when selecting the most appropriate concentration index for this project, to illustrate most closely the type of inequity this project intended to measure. Both W(h) and E(h) satisfy three properties considered to be desirable for any concentration index: the transfer property, the mirror property, and the property of cardinal invariance.[186] A description of these properties can be seen in Appendix E. The Wagstaff index and the Erreygers index differ in two key properties. The first is the

approximation of a relative or an absolute index of inequality, and the second is the definition of the most inequitable society.

3.4.2. Relative vs Absolute Indices

An *absolute index* to measure inequality has level independence, meaning that if all individuals receive an equal incremental change in some measure, the absolute inequality has not changed.[186,189] That is, if one person has 10 dollars and another has 60 dollars, the measured inequity will be the same as comparison to a situation where that same person has 20 dollars and the other has 70 dollars. In this case the absolute difference has stayed the same. By comparison, a *relative index* has scale independence when measuring inequity, which results in no change in the measure of inequity when all individuals experience an equiproportionate (or relative) change in the measured variable.[186,192] Using the same example as above, a relative index would find that inequity decreased: in the first scenario one person had six times more wealth, where in the second scenario, they had only 3.5 times more, decreasing relative inequity.

When measuring inequity using binary variables, such as health resources, each individual in the population either has a given health resource or does not (either is vaccinated or is not). As a result there is a finite maximum amount of that health resource possible, in which all individuals have that health resource (all individuals are vaccinated).[189,193] A relative index result measures the difference in health between individuals, relative to the coverage of the health resource in the population.[186,189] If the absolute difference in health resources between groups is maintained, as the overall coverage increases, a relative index will result in a score closer to zero, suggesting greater equity. The absolute measure, by comparison, is not dependant on the coverage of the health resource.[193] For an absolute measure, if the absolute difference in the measure of the health resource between groups is maintained, the overall coverage in the population will not affect the resulting estimate, and the resulting score will stay the same.[186,193]

The Erreygers index acts as an absolute index, producing an identical index score, regardless of coverage, as long as the absolute difference in coverage between groups is maintained. The Wagstaff index is neither a true relative nor a true absolute index. As a result, the interpretation of W(h) is more difficult.

3.4.3. Definition of most inequitable

When applied to unbounded variables, the C(h) ranges from -1 to 1. In the most-extreme cases, the most inequitable cases, the entire measured variable (wealth, or health, etc.) is concentrated in the single poorest or wealthiest individual.[184] For any alternative distribution of health or wealth, the index value indicates to what extent the measured variable is concentrated within the wealthy or poor, as a point estimate ranging from -1 to 1.[184] This holds true for measured variables that are continuous and have no upper bounds.

When the variable of interest is binary, the true range of the concentration index C(h) is not from -1 to 1, but from the coverage (μ) minus one (μ-1), to one minus the coverage (1- μ) seen in Figure 11.[185] This means that for higher coverage, closer to 100%, the range of possible equity estimates is smaller than for lower coverage. The Erreygers and Wagstaff indices both address this issue, but differ in how they have each defined the most inequitable society. There is no "correct" way to define the most inequitable; the choice is arbitrary, and it has implications for the resulting index scores, so is important to understand.

Wagstaff W(h) adjusts the calculation of the concentration index C(h) so that the most inequitable scenario is defined as a circumstance in which the wealthiest proportion of the population, equal to the level of coverage in the population, has all the measured health resource.[192] In practice, it means that if there is 10% vaccination coverage, the wealthiest 10% of the population will have all the vaccinations, and the rest of the population will have none. Likewise, if there is 30% vaccination coverage, the wealthiest 30% of the population will have all the vaccinations. In both these cases, the value of W(h)=1, as it represents the most inequitable distribution, by Wagstaff's definition, given the coverage.[192] As a result, the interpretation of W(h), especially when comparing different programmes, is difficult, without knowing the coverage levels for each programme.

The Erreygers index, by comparison defines the most inequitable society independent of the measured coverage in the population being analysed. In all cases, regardless of the true coverage of the health resource in the population where the index is being applied, the Erreygers index defines the most inequitable society as one in which the wealthiest 50% of the population has 100% coverage of the health resource, and the poorest 50% of the population has none.[189] If we use the same examples as above, the E(h) for the 10% vaccination coverage concentrated in the wealthiest 10% of the population would produce a more equitable index score than the population with 30% vaccination coverage concentrated in the wealthiest 30% of the population.[189,192] The E(h) = 1 (or -1) only when the overall coverage is

50% and the measured health resource is entirely concentrated in the wealthiest or the poorest half of the population.[189,193]

3.4.4. Comparison of W(h) and E(h) in practice

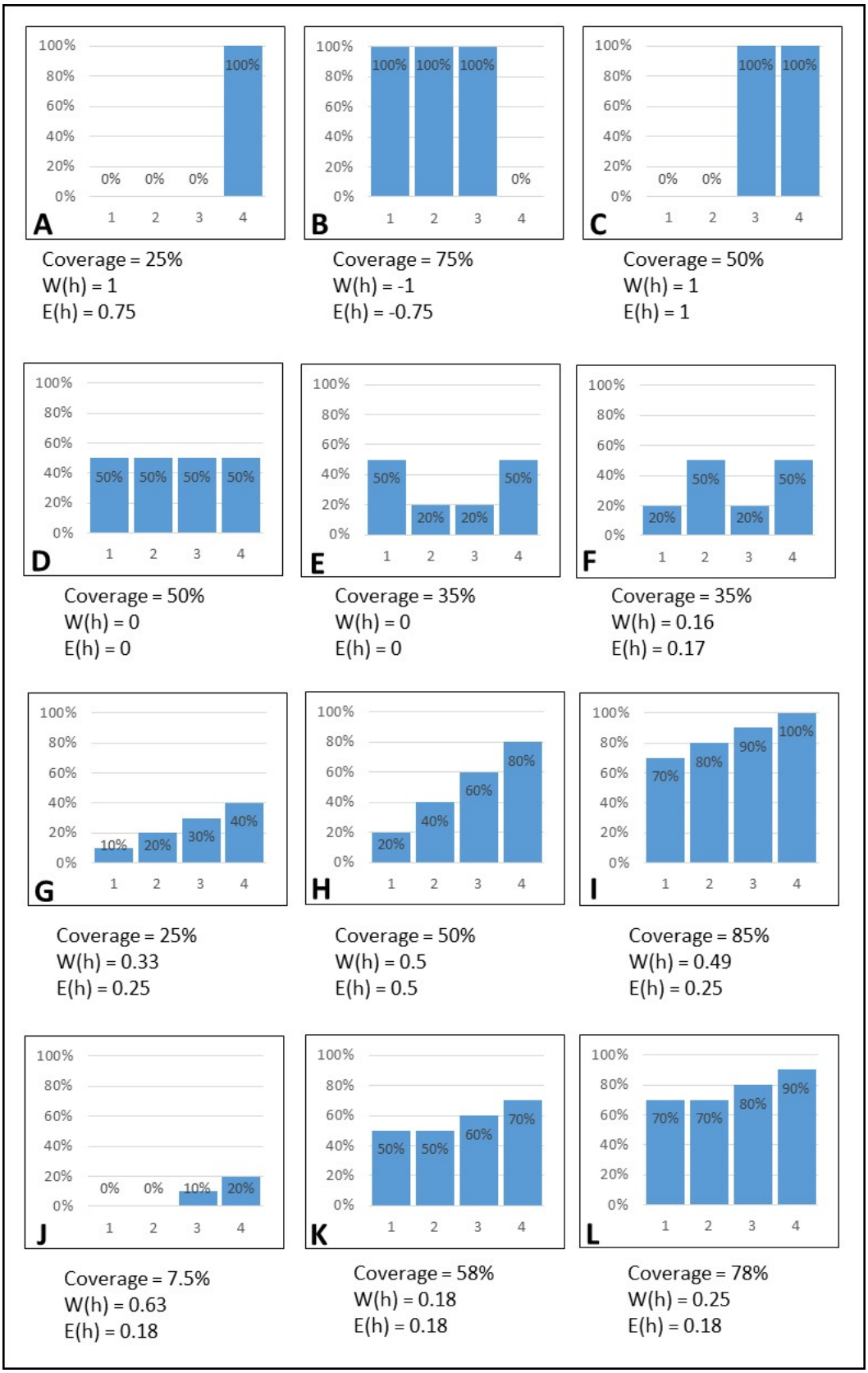
Figure 12 illustrates the differences and similarities between the Wagstaff and Erreygers indices when applied to different coverage distributions. Boxes A and B show the mirror property, resulting in indices with the same absolute value and opposite signs. While A, B and C all illustrate W(h) definition of the most inequitable, and produce a W(h)= 1, only box C represents the Erreygers definition of the most inequitable. Box C is the only scenario where both W(h) and E(h) will produce an index equal to 1.

Box D illustrates a perfectly equitable distribution between the wealth quartiles, producing an index equal to 0 for both W(h) and E(h). Box E also produces an index score equal to 0 for both W(h) and E(h). Box F has a nearly identical index value for both W(h) and E(h) of 0.36. Box E and F illustrate one of the drawbacks of concentration indices – a single point estimate cannot fully describe a complex system.

In boxes G, H and I, we begin to see the differences between E(h) and W(h) emerge, when applied to more real-life scenarios. Boxes G and H have the same relative scale between the wealth quartiles. We would expect E(h) to find box H less equitable, as the relative difference increase, and that is what we see. Likewise, if W(h) was a purely relative index, we would expect W(h) to stay the same, but it is not, and so it does not. The change in W(h) is not as large as the change in E(h), but both indices score box H less equitable than box G. When we compare box G to box I, the absolute difference between the wealth quartiles is now the same, so we expect E(h) to find these two scenarios equally inequitable, which is does. Comparing boxes H and I, neither the overall coverage, the relative difference, or the absolute difference is maintained, and yet W(h) finds these two scenarios nearly identical in terms of inequity.

Boxes J, K, and L all have identical absolute differences when comparing wealth quintiles. As expected, E(h) produces identical index scores for these three scenarios. By comparison, W(h) finds box K to be the most equitable of the three, and find box J to be the lease equitable. The W(h) index results are more difficult to interpret. At the highest and lowest levels of coverage, the W(h) index suggests greater inequity, as a result of Wagstaff's definition of the most inequitable.

Figure 12: Concentration index examples using W(h) and E(h) in different scenarios



* Hypothetical programme coverage on the vertical axis of each box, and wealth quartiles from poorest to richest on the horizontal axis of each box

3.4.5. Use in this analysis

The analysis presented in chapter 8 aims to compare the distribution of ITNs, ANC and EPI in 25 countries, and to measure the level of inequity for each programme. All three of these programmes are measured using a binary variable for coverage: broadly, the proportion of children sleeping under an ITN, the proportion of women attending ANC, and the proportion of children attending EPI. As a result, to measure inequity, either the Wagstaff or the Erreygers concentration indices for binary variables is necessary.[185,186]

The coverage levels vary for each programme, and in each country. The objective was to look at inequity separately from coverage. The Wagstaff index W(h) provided a single estimate that mixed these measures, making the interpretation of the index more difficult. The Erreygers index behaves like an absolute index, which allows the inequity measure to be independent of the coverage measured in the population. At the highest levels of coverage, E(h) will converge on zero, but at coverage above 80%, E(h) can still provide estimates of pro-poor and pro-rich distribution. Erreygers' standard definition of the most inequitable is also an important factor for the analysis presented later in this thesis. By providing a theoretical "most inequitable" which doesn't change as coverage changes in any programme or country, all the measures of inequity produced by the index can be more easily compared to each other.

With these differences in mind, the Erreygers index for health, E(h), was selected for use in this thesis to compare the inequity of programme distribution within, and between, countries.

RESULTS

Chapters four through eight present the results of this thesis. Each chapter aims to address one of the research objectives. A variety of methods and data sources have been used to address these objectives. Each results chapter is presented in the form of an independent research paper for publication. Three of these chapters have been published (chapters 4, 5, and 6) and two have not yet been submitted (chapter 7 and 8).

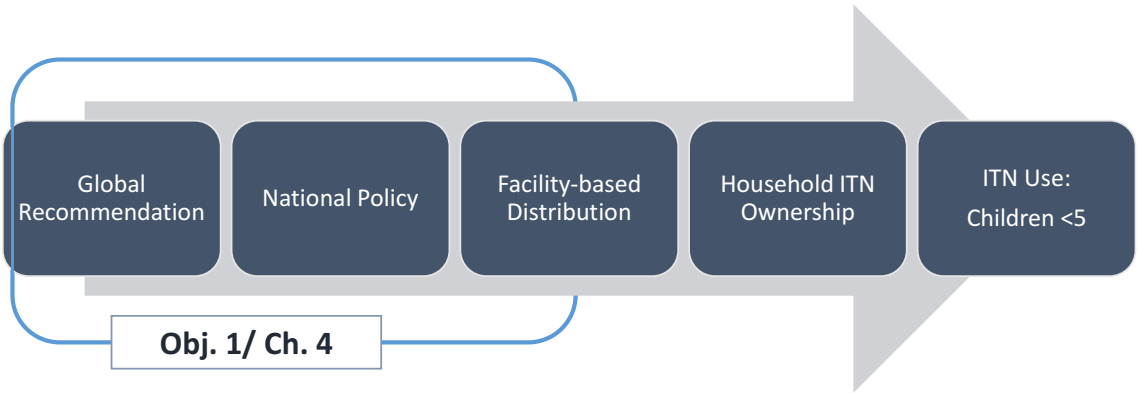
Each chapter includes a background, methods, results, discussion and conclusion section. A cover page for each chapter is also included, required by LSHTM, which outlines the publication status of each chapter. An introduction page is also included with each chapter describing how it fits within the overall thesis. The methods section of each chapter discusses the methods used, but more detailed information on selected methods were presented in chapter 3.

CHAPTER 4: ASSESSING THE AVAILABILITY OF LLINS FOR CONTINUOUS DISTRIBUTION THROUGH ROUTINE ANTENATAL CARE AND THE EXPANDED PROGRAMME ON IMMUNIZATION IN SUB-SAHARAN AFRICA

Chapter 4 addresses the first objective of this thesis, to analyse the availability of LLINs through routine channels, and assess the missed opportunities for ITN distribution to women and children through these channels. This is likely the first analysis to compare ITNs distributed via ANC and EPI with routine attendance records for these programmes. This chapter adds to our understand of the current uptake of routine facility-based ITN distribution throughout Africa, as well as the extent to which these distribution channels are reaching the intended beneficiaries of women attending ANC and infants attending EPI.

This chapter assesses the national policies in place across Africa, and the implementation of those policies for routine facility-based ITN distribution through ANC and EPI. It focuses on the national and international levels of the health system, using aggregated data to understand the uptake of this programme at a national level, and across the African continent (Figure 13). The dataset used in this analysis is the aggregation of reports provided to WHO by national malaria control programmes on ITN distribution policies, and programme planning. This dataset does not include information on individual ownership and use of ITNs.

Figure 13: Process elements included in Chapter 4



This chapter begins with the LSHTM Cover Sheet for research papers included in a research thesis. The chapter includes, in the discussion, two boxes which investigate alternative

scenarios in which ITN distribution via these channels is scaled-up to meet the need of women and children attending ANC and EPI.

An abbreviated version of this analysis was included in the 2013 World Malaria Report. The complete analysis is presented here.

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SECTION A – Student Details

Student	Katherine Theiss-Nyland
Principal Supervisor	Paul Fine
Thesis Title	Integrating insecticide treated nets with routine antenatal care and immunization programmes: policy, practice, and coverage

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

Where was the work published?	Malaria Journal		
When was the work published?	4 May 2016		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	n/a		
Have you retained the copyright for the work?*	**Yes**	Was the work subject to academic peer review?	**Yes**

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SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I am the first author on this paper. I was responsible for the study design and analysis. I also wrote the complete article. The co-authors supported this work as advisors, providing feedback on the direction of the research and assisting in editing and writing.

Student Signature: [redacted] **Date:** _20/03/2017___

Supervisor Signature: [redacted] **Date:** __20/03/2017__

Assessing the availability of LLINs for continuous distribution through routine antenatal care and the Expanded Programme on Immunization in sub-Saharan Africa

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4.1. Abstract

Background

In addition to mass distribution campaigns, the World Health Organization (WHO) recommends the continuous distribution of long-lasting insecticidal nets (LLINs) to all pregnant women attending antenatal care (ANC) and all infants attending the Expanded Programme on Immunization (EPI) services in countries implementing mosquito nets for malaria control. Countries report LLIN distribution data to the WHO annually. For this analysis, these data were used to assess policy and practice in implementing these recommendations and to compare the numbers of LLINs available through ANC and EPI services with the numbers of women and children attending these services.

Methods

For each reporting country in sub-Saharan Africa, the presence of a reported policy for LLIN distribution through ANC and EPI was reviewed. Prior to inclusion in the analysis the completeness of data was assessed in terms of the numbers of LLINs distributed through all channels (campaigns, EPI, ANC, other). For each country with adequate data, the numbers of LLINs reportedly distributed by national programmes to ANC was compared to the number of women reportedly attending ANC at least once; the ratio between these two numbers was used as an indicator of LLIN availability at ANC services. The same calculations were repeated

for LLINs distributed through EPI to produce the corresponding LLIN availability through this distribution channel.

Results

Among 48 malaria-endemic countries in Africa, 33 malaria programmes reported adopting policies of ANC-based continuous distribution of LLINs, and 25 reported adopting policies of EPI-based distribution. Over a three-year period through 2012, distribution through ANC accounted for 9% of LLINs distributed, and LLINs distributed through EPI accounted for 4%. The LLIN availability ratios achieved were 55% through ANC and 34% through EPI. For 38 country programmes reporting on LLIN distribution, data to calculate LLIN availability through ANC and EPI was available for 17 and 16, respectively.

Conclusions

These continuous LLIN distribution channels appear to be under-utilized, especially EPI-based distribution. However, quality data from more countries are needed for consistent and reliable programme performance monitoring. A greater focus on routine data collection, monitoring and reporting on LLINs distributed through both ANC and EPI can provide insight into both strengths and weaknesses of continuous distribution, and improve the effectiveness of these delivery channels.

4.2. Background

Long-lasting insecticidal nets (LLINs) have been the mainstay of vector control for malaria prevention. The World Health Organization (WHO) recommends universal coverage of LLINs, defined as one LLIN for every two people within a household, for malaria-endemic countries and regions.[68] Eighty-eight countries, 39 in Africa, distribute LLINs free of charge.[1] The main channel for LLIN distribution since the early 2000s has been mass campaigns. Since 2007, WHO has also recommended the continuous distribution of LLINs to all pregnant women through routine antenatal care (ANC) and to all children under one year through the Expanded Programme on Immunization (EPI), to complement campaigns, and maintain coverage of the most biologically vulnerable people during the intervals between mass campaigns.[65,66,68,194]

The routine health services of ANC and EPI have important advantages as LLIN distribution points because their target populations are especially vulnerable to malaria, and because, compared to other health services, they tend to achieve relatively high and equitable levels of access for these target groups in most countries. Globally, approximately 83% of women receive ANC at least once during their pregnancy,[195] and 85% of children complete their

vaccination schedule.[196] In 41 of 45 countries in the WHO African Region, the policy is to distribute LLINs free of charge.[10] In countries with an ANC distribution policy, the first ANC visit is generally used as the point-of-contact for LLIN distribution, in line with the WHO recommendation.[66] There is no specific WHO recommendation as to when LLINs should be distributed in EPI,[66,68] and a wide range of time-points is used in practice, from birth (with BCG vaccine for tuberculosis) to nine months of age (with measles vaccine). Diphtheria-tetnus-pertussus-1 (DTP1) vaccination at six weeks of age is the most common distribution point.[66]

Each year, to prepare for the production of the World Malaria Report, national malaria programmes in endemic countries provide WHO with data on the adoption of LLIN distribution policies and the total LLINs made available for distribution through all channels (campaign, ANC, EPI, other).[1,8] These data have not previously been used to assess the extent to which ANC and EPI distribution channels have been utilized for LLINs in practice. The WHO has collected reports of the numbers of nets distributed since 2000 at country level, and in this analysis national programme reports of the nets distributed through ANC or EPI were compared with reports of the total number of women attending ANC or children attending EPI, to calculate an LLIN availability ratio for each channel.

4.3. Methods

The LLIN continuous distribution policies were assessed for African countries using the policy information reported to WHO. A country was considered to have a policy for ANC and/or EPI distribution of LLINs if it declared the existence of a policy in its annual report to WHO on or before the year 2012. The report to WHO included both the existence of a policy and the year the policy was adopted. The delay in policy implementation was assessed by comparing the year of policy adoption to the first year in which the country reported distributing any LLINs through the relevant distribution channel.

The volume of LLINs distributed through ANC and EPI was assessed for countries in Africa, using the sum of LLINs distributed through all channels (campaigns, EPI, ANC, and other channels). The completeness of data available was assessed in terms of missing values and inconsistencies in reported totals. Annual reports that did not include specific information on the channel of distribution, or where the channel totals did not add up to within 10% of the reported total nets distributed were excluded from the analysis. Countries were eligible for inclusion if they had reported complete distribution channel data in at least three of the four years from 2009 to 2012. If there were data for all four of these years, the most recent three

years (2010-2012) were included. In all included countries, campaign nets were distributed in at least one of the included years. The most recent three years of data from each country were aggregated to account for year-to-year variation, especially due to campaigns.

The numbers of nets reportedly distributed through each distribution channel were summed over all included countries, to produce the proportion of the total nets reportedly distributed through each channel. An example of this calculation for ANC:

$$\frac{\Sigma(LLINs\ distributed\ via\ ANC)}{\Sigma(LLINs\ distributed\ via\ all\ channels)} = Proportion\ LLINs\ distributed\ via\ ANC$$

For countries reporting at least three years of LLINs distributed via ANC or EPI, an LLIN availability ratio was calculated. The LLIN availability ratio for a distribution channel represents the total number of nets reportedly distributed through the service relative to the total number of women or children attending that service. To assess whether the number of nets made available through ANC was sufficient to allow one LLIN to be given to every pregnant woman attending ANC, an ANC LLIN availability ratio pooling data across all included countries with LLIN distribution through ANC was calculated:

$$\frac{\Sigma\ (LLIN\ reported\ distributed\ via\ ANC)}{\Sigma\ (women\ reported\ attending\ ANC)} = ANC\ availability\ ratio$$

For the ANC availability ratio, both the denominator and numerator were reported by national malaria control programmes to the WHO Malaria Control Programme.

Similarly, for EPI, an LLIN availability ratio was calculated to assess whether the number of LLINs made available through this channel was sufficient for all the infants attending EPI services, pooling data across all included countries with LLIN distribution through EPI:

$$\frac{\Sigma\ (LLIN\ reported\ distributed\ via\ EPI)}{\Sigma\ (infants\ reported\ attending\ EPI)} = EPI\ availability\ ratio$$

In this case, the denominator (total infants attending EPI) was taken from a different source than the numerator: EPI coverage reports submitted to WHO by national EPI authorities. Because there is no clear consensus or recommendation as to the best age for LLIN distribution in EPI, two different LLIN availability ratios were calculated for EPI, using either the number of children who received DTP1 vaccination (normally at six weeks of age) or the number receiving measles vaccination (normally at six months of age).

$$\frac{\Sigma\,(LLIN\ reported\ distributed\ via\ EPI)}{\Sigma\,(infants\ reported\ receieving\ DTP1)} = EPI\ (DTP1)\ availability\ ratio$$

and

$$\frac{\Sigma\,(LLIN\ reported\ distributed\ via\ EPI)}{\Sigma\,(infants\ reported\ receiving\ measles\ vaccine)} = EPI\ (Measles)\ availability\ ratio$$

In most countries, DTP1 coverage is higher than measles vaccination coverage, so the DTP1 vaccination comparison provides a more conservative estimate of LLIN availability.

4.4. Results

Control programmes in malaria-endemic countries began reporting LLIN distribution data annually to WHO in 2008, and were asked at that time to provide historical data back to 2000. The review of data completeness revealed that no single African country reporting to WHO included complete distribution channel data for years before 2008. From 2008 onwards, most countries were reporting complete distribution channel data, but a large minority of reports each year still did not break down the data by distribution channel, up through the 2012 reports.

In 2012, of the 48 African countries reporting LLIN data to the WHO, 33 country programmes reported having a policy for LLIN distribution through ANC, and 25 reported having a policy for LLIN distribution through EPI. Of the 33 countries with a reported ANC distribution policy, one country had never reported implementation since policy adoption in 1998. Of the 25 countries with a reported EPI-based distribution policy, six countries had never reported implementation since policy adoption in years between 1998 and 2008. Furthermore, in Africa, seven countries reported distributing LLINs through ANC without having reported adopting an ANC LLIN distribution policy, and five countries reported distributing LLINs via EPI without having reported adopting an EPI LLIN distribution policy. ANC policies took an average of 2.3 years to be implemented (median: 2 years), while EPI policies took an average of 2.7 years to be implemented (median: 2 years). The range for this interval was wide, and in a few countries there were long delays: up to 11 and nine years, for ANC and EPI, respectively.

In total, 38 country programmes were included in the analysis of continuous distribution (Table 10). In these countries (representing a population of approximately 805,404,900 people in 2012), 290,030,923 LLINs were distributed during the three-year window. Of these, 86% were reportedly distributed via mass campaigns, 9% via ANC, 4% via EPI, and 2% via other channels.

Table 10: Reporting country programmes data years included, total number of nets distributed, and inclusion on different parts of continuous distribution analysis

	COUNTRY PROGRAMMES	YEARS INCLUDED	TOTAL NETS	DISTRIBUTION CHANNEL PROPORTION ANALYSIS*	ANC AVAILABILITY RATIO ANALYSIS**	EPI AVAILABILITY RATIO ANALYSIS***
WEST	Benin	09, 11, 12	6,720,585	y	y	y
	Burkina Faso	10, 11, 12	7,930,794	y	y	y
	Côte d'Ivoire	09, 10, 11	9,221,508	y		y
	Gambia	09, 11, 12	1,182,883	y	y	y
	Ghana	10, 11, 12	13,042,900	y		
	Guinea-Bissau	10, 11, 12	1,179,669	y	y	y
	Liberia	09, 10, 11	2,474,400	y		
	Mali	10, 11, 12	7,128,578	y	y	y
	Nigeria	10, 11, 12	51,456,461	y		
	Senegal	09, 10, 11	5,342,486	y		
	Sierra Leone	10, 11, 12	3,598,535	y	y	y
	Togo	10, 11, 12	3,124,868	y	y	y
CENTRAL	Angola	10, 11, 12	3,876,147	y	y	y
	Cameroon	09, 10, 11	8,733,485	y		
	Central African Republic	09, 10, 12	1,078,274	y		
	Chad	09, 10, 11	3,909,081	y		y
	Democratic Republic of Congo	10, 11, 12	32,952,748	y	y	y
	Equatorial Guinea	09, 11, 12	19,035	y	y	
	Sao Tome and Principe	10, 11, 12	157,700	y	y	
SOUTH	Botswana	10, 11, 12	148,500	y		
	Mozambique	10, 11, 12	7,439,387	y	y	
	Swaziland	10, 11, 12	159,805	y		
EAST	Burundi	10, 11, 12	4,751,975	y		y
	Comoros	10, 11, 12	270,120	y		
	Djibouti	10, 11, 12	54,800	y		
	Eritrea	10, 11, 12	1,179,640	y		
	Ethiopia	10, 11, 12	24,337,326	y		
	Kenya	10, 11, 12	14,461,002	y	y	y
	Madagascar	10, 11, 12	9,436,883	y	y	y
	Malawi	10, 11, 12	9,289,178	y	y	
	Rwanda	10, 11, 12	7,255,887	y		y
	Somalia	10, 11, 12	796,698	y		
	Sudan	10, 11, 12	3,692,659	y		

	Tanzania (mainland)	10, 11, 12	24,573,301	y	y	y
	Tanzania (Zanzibar)	09, 10, 11	348,250	y		
	Uganda	10, 11, 12	9,109,747	y		
	Zambia	10, 11, 12	7,278,762	y	y	
	Zimbabwe	09, 10, 12	2,316,866	y		
	Total: 38		290,030,923	38	17	16

Data source: Total nets distributed annually, reported by national malaria control programmes to the WHO Global Malaria Programme

* Countries included in the analysis of the proportion of total nets distributed through each channel

** Countries included in the analysis of ANC availability ratio: the number of nets reportedly distributed via ANC over the number of women reportedly attending ANC services

*** Countries included in the analysis of the EPI availability ratio: the number of nets reportedly distributed via EPI over the number of children reportedly attending EPI services

Seventeen countries had sufficient data to be included in the ANC availability ratio calculation, and 16 had sufficient data to be included in the EPI availability calculation (Table 11). The ANC LLIN availability ratio, in countries with active distribution for this channel, was 55% (Table 11). Thus, LLINs reportedly distributed via ANC were sufficient to provide one LLIN to 55% of the women reportedly attending this service. The LLIN availability ratio for EPI was calculated using both DTP1 and measles visits as denominators. With the DTP1 visits as denominator, the availability ratio for countries actively distributing LLINs through EPI was 34% (Table 11). With measles vaccination visits, the availability ratio was 37% (Table 11). Thus, LLINs reportedly distributed via EPI were sufficient to provide one LLIN to 34-37% of the infants attending this service. When availability ratios were calculated for individual countries, performance varied greatly for both ANC and EPI distribution, with the lowest availability ratios below 10%, and the highest greater than 90%.

Table 11: Comparison of ANC and EPI-based LLIN distribution in African countries

	ANC	EPI	
Policy and implementation			
Countries with a reported distribution policy	33	25	
Average years between policy and implementation	2.3	2.7	
Proportion of LLINs distributed via each channel			
Proportion of total LLINs distributed through the channel	9%	4%	
Distribution channel availability ratio	ANC	DTP1	Measles
Availability ratio	55%	34%**	37%***
Missed Opportunities through channel*	45%	66%**	63%***

* The proportion of reported women attending ANC or children attending EPI for whom an LLIN was not available
** Ratio calculated using the number of children who received DTP 1 vaccination as the denominator
*** Ratio calculated using the number of children who received Measles vaccination as the denominator

4.5. Discussion

These availability ratios suggest that in countries where LLIN distribution was occurring through ANC and EPI, the number of LLINs distributed to ANC and EPI clinics was not enough to allow every woman or child attending these services to receive an LLIN (as recommended by WHO). Consequently, nearly half of women attending ANC and more than 60% of infants attending EPI represent a missed opportunity to distribute an LLIN to a pregnant woman or child possibly in need of one (Table 11). This suggests that both ANC and EPI visits are under-utilized for distribution of LLINs by national malaria programmes and international funding agencies, whether estimated using distribution data (Figure 14) or population data (Figure 15). It is worth noting that the policies in place may not specify that LLINs should be given to all women and children attending ANC and EPI, as stated in the WHO recommendation.[68]

Figure 14: Scale-up of LLIN distribution - calculation based on previous distribution

The total LLINs distributed in a three-year period via all channels by the 38 countries included in the analysis was:

$$252{,}033{,}272 = LLINs\ distributed\ via\ campaigns\ (86\%)$$
$$24{,}657{,}101 = LLINs\ distributed\ via\ ANC\ (9\%)$$
$$11{,}231{,}333 = LLINs\ distributed\ via\ EPI\ (4\%)$$
$$4{,}868{,}165 = LLINs\ distributed\ via\ other\ chanels\ (2\%)$$
$$292{,}789{,}871 = Total\ LLINs\ distributed\ *$$

Assume that ANC LLINs are available for 55% of women attending ANC, and EPI LLINs are available for 34% of children attending EPI in these countries

To scale up LLINs to cover 100% of women and children attending ANC and EPI to following calculation is done:

$$\frac{11{,}231{,}333\ LLINs}{33{,}033{,}332\ \ LLINs} = \frac{34\%\ of\ EPI}{100\%\ of\ EPI}$$

$$\frac{24{,}657{,}101\ LLINs}{44{,}831{,}093\ LLINs} = \frac{55\%\ of\ ANC}{100\%\ of\ ANC}$$

Assume LLIN distribution via campaigns and other channels remains the same

The proportion of LLINs needed for 100% of women attending ANC:

$$\frac{\text{Total ANC LLINS}}{\Sigma\ \text{Campaign} + \text{ANC} + \text{EPI} + \text{Other channel LLINs}} = \%\ of\ Total\ LLINs$$

$$\frac{44{,}831{,}093\ LLINs}{334{,}765{,}862\ LLINs} = 13\%\ of\ Total\ LLINs$$

The proportion of LLINs needed for 100% of infants attending EPI:

$$\frac{\text{Total EPI LLINS}}{\Sigma\ \text{Campaign} + \text{ANC} + \text{EPI} + \text{Other channel LLINs}} = \%\ of\ Total\ LLINs$$

$$\frac{33{,}033{,}332\ \ LLINs}{334{,}765{,}862\ LLINs} = 10\%\ of\ Total\ LLINs$$

In total 23%, or approximately one quarter, of LLINs would be distributed through ANC and EPI if the volume of nets was increased to provide LLINs to 100% of women and children attending these services, in countries that are already providing this service.

*The sum total of the LLINs distributed via the distribution channels does not equal the total nets reportedly distributed via each country (Table 10). The different may be due to some double reporting of nets, if they were distributed in a targeted campaign effort. To avoid significantly over-counting nets, countries were excluded if the sum of nets distributed via all channels was not within 10% of the total reported nets distributed.

Figure 15: Scale-up of LLIN distribution - calculation based on population

The total population of 38 countries included in this analysis in 2012 was:

$$805{,}404{,}900 = \text{Total population}$$

Assume campaign nets are distributed once every three years, and are provided to the entire populations, with one net for every 2 people per household. Accounting for households with odd numbers of people, the nets needed is 1 net per 1.8 people:

$$\frac{805{,}404{,}900}{1.8} = 447{,}447{,}167\ nets$$

Assume ANC nets are provided to every woman attending ANC, and that 80% of pregnant women attend ANC.
Assume 5% of the population is pregnant every year

$$((805{,}404{,}900 \times 0.05) \times 3 years) \times 0.80 = 96{,}648{,}588\ nets$$

Assume EPI nets are needed for every child attending immunization services, and that 80% of children under 1 will attend EPI.
Assume 4% of the population is a child under 1 year, every year

$$\big((805{,}404{,}900 \times 0.04) \times 3 years\big) \times 0.80 = 77{,}318{,}870\ nets$$

Total nets needed in a three-year period, based on population:

$$447{,}447{,}167\ nets = campaign\ nets\ (72\%\ of\ total)$$
$$96{,}648{,}588\ nets = ANC\ nets\ (16\%\ of\ total)$$
$$77{,}318{,}870\ nets = EPI\ nets\ (12\%\ of\ total)$$
$$621{,}414{,}625 = Total\ nets$$

In total 27%, or approximately one quarter, of LLINs would be distributed through ANC and EPI if the volume of nets distributed accounted for 80% of all the pregnant women and 80% of all the children under 1 year of age, in countries that are already providing this service.

This shortfall in LLINs for continuous distribution through ANC and EPI could be due to under-allocation of LLINs from national central supplies to facilities for use in these channels. Webster and colleagues identify an inconsistent supply of LLINs at facilities as a barrier to continuous distribution through ANC[101] and Theiss-Nyland and colleagues identified frequent stock-outs and stock shortages of LLINs intended for ANC and EPI based distribution.[197] However, LLINs are often allocated towards a specific distribution channel before arriving in country, based on funding allocated to different distribution methods. This shortfall in meeting the needs of these distribution programmes is likely due to inadequate supply of LLINs to countries (Figure 14 and Figure 15). By these calculations, more than 40 million additional nets, or approximately one quarter of the total nets distributed, may be needed to meet the demand of ANC and EPI programmes (Figure 14 and Figure 15). The Global Fund to Fight AIDS, Tuberculosis and Malaria (GF) includes "[the] number of long-lasting insecticidal nets distributed to targeted risk groups through continuous distribution" as a core indicator for

malaria programme monitoring.[198] However, this target does not require a population-based denominator.[198] This number is compared to the target set by the programme.[198] As a result, countries are not required to compare the number of LLINs provided against the populations attending continuous distribution services (as has been done in this paper). If the indicators recommended by key funding institutions measure only whether or not there is provision of LLINs to pregnant women and infants, and not the completeness of that provision, country programmes may have little financial incentive to monitor and improve the adequacy and effectiveness of the supply of nets.

While it appears that ANC-based continuous LLIN distribution has been more effectively implemented than EPI-based distribution, national programmes only reported distributing enough LLINs through ANC for half the number of women attending ANC at least once. The higher availability ratio seen in ANC-based distribution may be the result of greater emphasis and focus on this channel, as part of broader efforts to combat the effects of malaria in pregnancy. While many studies have investigated ANC-based distribution,[86,98,101,103,199] only one pilot programme was found that focused on EPI-based LLIN distribution.[48] Under-utilization of these continuous distribution channels could be one factor preventing programmes from achieving or maintaining universal LLIN coverage.

These findings also suggest that, despite WHO recommendations for continuous distribution, most countries are still relying heavily on mass distribution campaigns to distribute LLINs. These campaigns are often still necessary for increasing national LLIN ownership and maintaining coverage, but pregnancies and births that occur between campaigns represent vulnerable populations potentially unprotected without effective continuous distribution programmes. Likewise, campaign nets that degrade over time need to be replenished through continuous distribution channels in order to maintain high coverage.

The dataset used to make these comparisons presents a number of limitations. The quantities of LLINs distributed, and the number of women and children attending ANC and EPI services are assumed to be the best estimates from service delivery records and surveys in each country and year included. These are the only data available at a national level on the total nets distributed via different channels. However, there were too many missing data points for LLIN quantities in the dataset before the year of 2009, which limited the analysis to three years, and made historical comparisons before continuous distribution recommendations impossible. The EPI attendance numbers were provided by WHO EPI nationally reported vaccination coverage, and survey data.[138] The ANC numbers, by comparison, were reported by

the national malaria control programmes from each country, along with the LLIN information. Although 30 countries reported distributing LLINs via ANC in the years included, only 17 of those countries provided ANC attendance numbers, limiting the analysis. A possible bias could be that only countries with better ANC distribution performance provided ANC attendance numbers. This means that the difference between ANC and EPI LLIN availability ratios may be a result of bias, rather than a true difference. The years of data included were not the same in all the countries, and eight out of the total 38 countries included in the analysis did not have three consecutive years of data due to incomplete reporting in some years (Table 10). The LLIN quantities reported likely represent the number of nets distributed from central storage to facilities in each country, while the number of ANC and EPI visits come from reported service delivery. Finally, only data up to 2012 were analyzed; more recent data may show improvements in distribution of LLINs through these channels.

Despite these limitations, this analysis is still useful to paint a broad picture of continuous distribution through ANC and EPI. While studies have modelled the potential coverage and the cost effectiveness of continuous distribution,[86,108–110] few studies have critically evaluated the extent to which continuous distribution is serving its target population.[101]

Beyond direct programme performance, this study also identified a deficiency in ANC and EPI-based continuous distribution programme monitoring and evaluation. Malaria programmes have relied on household surveys to monitor and assess the ownership and coverage of LLINs within a country. Surveys are arguably the best way to assess the outcome measures of LLIN ownership and use, but in the past most household surveys did not collect information on the source LLIN, making analyses like this very difficult. The most recent Demographic and Health Surveys 7 (DHS-7) questionnaire does include two questions intended to identify both the programme source and point of distribution for LLINs located in homes.[175] Unfortunately, the programme source of LLINs has yet to appear in the coded datasets from DHS-7 surveys in Africa that are available for analysis.[175] While information on the source of LLINs is a welcome addition to household survey data, data available from facilities and programmes, such as LLIN availability at the health facility and the proportion of women and infants who actually receive an LLIN out of those eligible, provide further insight about the process measures associated with programme performance.

Country malaria control programmes can adopt monitoring tools like these, which can serve as benchmarks for direct programme performance, and provide insight into areas of improvement for country programmes. Given the integrated nature of continuous distribution

via ANC and EPI, malaria programmes may be able to gain from both the experience of, and the systems put in place by, EPI and ANC in each country. By building routine data collection and reporting systems for LLIN service delivery, malaria programmes can monitor their performance against ANC and EPI, using routine health facility data, and identify areas that can serve as examples of best practices, and areas where more resources and support are needed.

4.6. Conclusion

These continuous LLIN distribution channels appear to be under-utilized, especially EPI-based distribution. This analysis illustrates the need to strengthen both the continuous distribution of LLINs, as well as the data collection and reporting systems necessary to effectively monitor a routine programme of this nature. However, quality data from more countries are needed for consistent and reliable programme performance monitoring. A greater focus on routine data collection, monitoring and reporting on LLINs distributed through both ANC and EPI can provide insight into both strengths and weaknesses of continuous distribution, and improve the effectiveness of these delivery channels. By building on the ANC and EPI service registers in use in countries, malaria programmes and international partners supporting these programmes, can take advantage of existing routine data structure to monitor programme performance. For integrated malaria programmes of this nature, sharing data with ANC and EPI programmes can also provide valuable estimations of target populations that can be reached through these channels. ANC and EPI services provide an important opportunity for LLIN distribution programmes to reach biologically vulnerable women and children, and fill gaps in population coverage. In order to take advantage of these distribution points, LLINs need to be made available, consistently, for all women and children attending these services.

4.7. Competing interests

The authors declare that they have no competing interests.

4.8. Authors' contributions

KTN and ML conceived and designed the analysis. KTN conducted the analysis and wrote the manuscript. KTN, ML and JL carried out the critical review of analysis and interpretations, and provided editorial input. All the authors have read and approved the final version of this article.

4.9. Acknowledgements

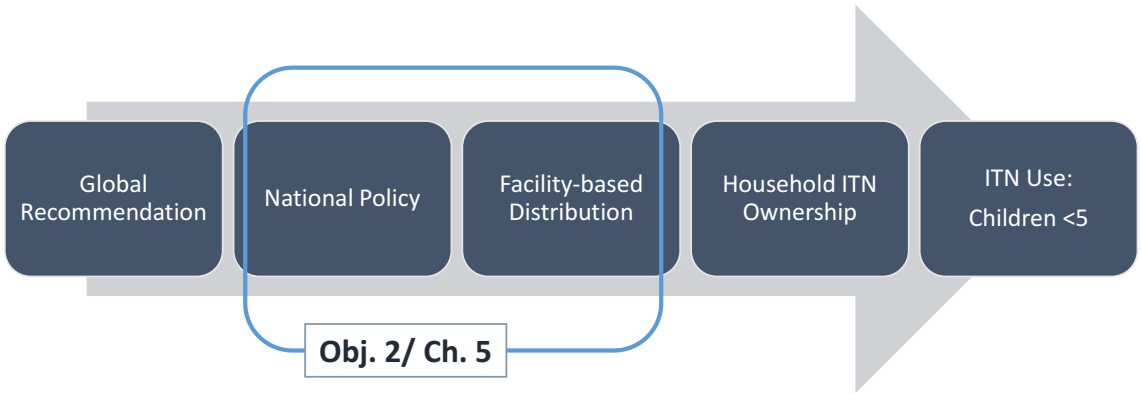
Some of the comparisons presented here were published in the 2013 World Malaria Report. Thank you to the World Health Organization Malaria Programme and Expanded Programme on Immunization for the access to these data.

CHAPTER 5: OPERATIONAL CHALLENGES TO CONTINUOUS LLIN DISTRIBUTION: A QUALITATIVE RAPID ASSESSMENT IN FOUR COUNTRIES

Chapter 5 addresses the second objective of this thesis, to evaluate the implementation of facility-based continuous distribution policies, and identify operational challenges, best practices, or bottlenecks that might be present.

This chapter aims to identify the barriers and bottle necks that might explain the missed opportunities for ITN distribution through ANC and EPI that were identified in chapter 4. This chapter takes a closer look at four countries with both ANC and EPI-based ITN distribution programmes, to understand how a national policy is implemented at the facility level, and the operational challenges that might exist (Figure 16).

Figure 16: Process elements included in Chapter 5



To achieve this, a qualitative analysis was conducted in four countries with the support of USAID and PMI. The work was funded by VectorWorks (formerly NetWorks) a USAID grant recipient. The design, implementation and analysis plan were developed independently. These plans were subsequently shared with staff from VectorWorks, USAID and PMI, to finalise the detailed plan before beginning the evaluation. The analysis first produced USAID reports for use by NMCP staff, USAID country teams, and partner organizations. Further analysis resulted in the publication included here.

This chapter includes also includes the LSHTM Cover Sheet for research papers included in a research thesis.

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SECTION A – Student Details

Student	Katherine Theiss-Nyland
Principal Supervisor	Paul Fine
Thesis Title	Integrating insecticide treated nets with routine antenatal care and immunization programmes: policy, practice, and coverage

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

Where was the work published?	Malaria Journal		
When was the work published?	1 March 2016		
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Have you retained the copyright for the work?*	**Yes**	Was the work subject to academic peer review?	**Yes**

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For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I am the first author on this paper. I was responsible for the study design and analysis. I also wrote the complete article. The co-authors supported this work as advisors, providing feedback on the direction of the research and assisting in editing and writing.

Student Signature: [redacted] **Date:** __20/03/2017___

Supervisor Signature: [redacted] **Date:** ___20/03/2017____

Operational challenges to continuous LLIN distribution: a qualitative rapid assessment in four countries

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5.1. Abstract

Background

The World Health Organization recommends that long-lasting insecticidal nets (LLINs) for malaria prevention should be distributed continuously through antenatal care (ANC) and the expanded programme on immunization (EPI) in addition to mass campaigns. Despite these recommendations, the continuous distribution (CD) of LLIN distribution through ANC and EPI is not policy in many countries, and where there is a policy, implementation is incomplete. This study aims to identify the operational strengths and weaknesses of LLINs CD in four country programmes in sub-Saharan Africa.

Methods

A qualitative rapid assessment process (RAP) was conducted using semi-structured individual and group interviews at the national, sub-national, and facility level in four countries. Seventy participants were included (23 in Kenya, 13 in Malawi, 18 in Mali and 16 in Rwanda), drawn from malaria programmes, ANC and EPI programmes, government logistics units, and partner organizations. Interviews were structured to identify themes within a health systems approach. Policy and guideline documents and data collection tools were reviewed as a means of triangulation. Data analysis focused on pre-determined and emergent themes.

Results

The four countries used a wide variety of management systems for the supply of LLINs to routine services. Issues related to quantification, supply logistics and data collection all contributed to stock-outs at facility level. None of the four countries had guidelines for responding to stock-outs or system enabling local staff to request additional supplies of LLINs. In all four countries, data collection of LLIN distribution was incomplete or absent at facility level, and such data were not used for planning. Training of staff at the facility level was implemented less frequently than national and sub-national staff would have preferred. Logistics systems, independent of other commodities, and in-country partner support strengthened the continuous distribution of LLINs.

Conclusions

In these countries, stock-outs were the most important single obstacle to the smooth operations of continuous LLIN distribution. Stock-outs can be avoided if facilities have the capacity to place orders for LLIN resupply as needed. Revised data collection and management systems for LLIN distribution have the potential to increase coverage of the target populations by improving LLIN stock-out response, and strengthening monitoring and evaluation of distribution.

Keywords

Continuous distribution, LLINs, routine distribution, monitoring and evaluation, rapid assessment process, ANC, EPI

5.2. Background

Long-lasting insecticidal nets (LLINs) are widely promoted for malaria prevention, and are distributed free of charge in 88 countries.[1] LLINs have been distributed primarily via large mass campaigns, following the success of the first national LLIN distribution campaign in Togo in 2004,[23] and thanks to funding from the Global Fund.[28] In 2007, the World Health Organization (WHO) began recommending both universal coverage campaigns and the continuous distribution of LLINs: providing LLINs to pregnant woman and infants through routine ANC and EPI services.[194] More explicit recommendations were later released, which further stressed the need for continuous distribution, and noted that, while campaigns were the most efficient method for rapidly scaling up LLIN ownership, a method which ensured a consistent stream of new nets entered communities, to maintain coverage between mass campaigns, was necessary.[65,66,68] "Giving higher priority to routine services, such as ante-natal clinics (ANC) and

the expanded programme on immunization (EPI) as a means of LLIN distribution to sustain Universal Coverage" was encouraged.[65] The WHO recommendation further states that, "Continuous distribution channels should be functional before, during, and after the mass distribution campaigns to avoid any gap in universal access to LLINs."[68]

In practice, there has been limited implementations of LLIN continuous distribution through ANC, and even less through EPI. Globally, 49 countries distribute LLINs through ANC, and 29 do so through EPI.[1] For those countries with continuous distribution, the 2013 World Malaria Report stated that in a three year period nets were only available for 55% of women attending ANC, and 34% of children attending EPI.[1]

Compared to LLIN campaigns, there has been less research on continuous LLIN distribution through ANC and EPI, and this research has tended to focus on the expected coverage which could be achieved, the feasibility of implementation, or the cost per net delivered.[73,80,84,86,98,101,102,106] Few studies have looked at the performance of these delivery systems at reaching their target groups, and the factors that influence the coverage that is actually achieved.[74,104]

The aim of this study was to examine the operational systems used to distribute LLINs through ANC and EPI in four African countries, as seen by the professional staff who manage and support the process, and to identify the strengths and weaknesses of these systems and the main operational barriers to better performance.

5.3. Methods

A qualitative Rapid Assessment Process (RAP) was conducted in Kenya, Malawi, Mali, and Rwanda between March and May of 2014. The RAP method uses iterative semi-structured interviews and triangulation to provide qualitative evidence for policy makers and programme planners in a limited time-frame.[151] The countries for this study were selected from 20 President's Malaria Initiative (PMI)-supported countries to include countries from both anglophone and francophone Africa, with a range of malaria transmission settings, a variety of continuous LLIN distribution experiences and policies, and a range of levels of coverage of LLIN, ANC and EPI services.

Two to four health facilities were selected in each country by the national malaria programme using purposive sampling, with input from local partner organizations. Purposive sampling was used to generate a "typical case sample" whereby the facilities in each country would

represent the normal or average service delivery, and could be compared across countries in the study.[200] Facilities were eligible for selection by the national malaria programme if they were non-urban, away from major roads, accessible from the capital within one day via car, in a malaria-endemic area, seen to be "average performing" in terms of malaria/LLIN delivery and general services, and the lowest level of health service delivery providing community health, maternity and EPI services (Kenya: Health Centres - level 3; Malawi: Health Centre; Mali: CSCOM; and Rwanda: Health Centre). In Kenya, four facilities were selected in Western and Nyanza provinces. In Mali, two facilities were selected in Koulikoro Region. In Malawi, one facility was selected in each of the three regions. Two Malawian facilities were government clinics, and one was supported by the Christian Health Association of Malawi (CHAM). One government facility originally selected was replaced due to reported heavy work-load of facility staff – the time available was not enough to wait until the end of clinic hours, and interrupting health services was not considered appropriate. In Rwanda, three facilities from the North and South were included in the study. In Rwanda, one of two originally selected facilities was unreachable due to heavy rains and flooding. As an alternative, two facility heads from two other facilities, who were at a nearby regional meeting, were opportunistically interviewed together.

At the national, sub-national, and facility levels, interviewees were purposively selected according to their role in the management or implementation of continuous LLIN distribution, ANC services, and/or EPI services. In total 38 interviews were conducted with 70 participants (Table 12). Semi-structured interviews were conducted with individuals or in small groups, depending on the availability and preference of interviewees. Interviews focused on the continuous distribution of LLINs through routine health services. In order to ensure that key health systems issues were covered, the interview guide was structured around the WHO "6 building blocks to health system strengthening": Service Delivery; Health Workforce; Information; Medical Products, Vaccines, and Technology; Financing; and Leadership and Governance.[166] The interview guides also included questions on ANC and EPI product logistics, and on the most recent mass LLIN distribution campaign and vaccination campaigns. Respondents were not asked to directly compare the logistics of different products. Probing questions and questions-of-clarification were used iteratively to explore key themes that arose, or when more information was required. An example interview guide can be seen in Appendix B. In addition to the interviews, policy and guideline documents were reviewed at the national level, and data collection tools and reporting forms at health facilities.

Interviews were conducted by two of the authors (KTN and YC), using English in Malawi and Kenya, French in Mali, and a combination of French and English in Rwanda. Before each interview began, the aims of the project were explained, information sheets were provided to each participant and written consent was obtained. Each interview was led by one team member, with the other team member taking notes and probing where further information was needed. All interviews were recorded, translated if in French, transcribed and entered into Nvivo10 for data management and analysis. The data were analysed by KT, starting with the previously-identified themes. The analysis was then further developed to explore additional emergent themes that were considered important for understanding the operational barriers to LLIN continuous distribution.

The protocol was reviewed and approved by the London School of Hygiene & Tropical Medicine (LSHTM) and the Johns Hopkins Bloomberg School of Public Health ethics review boards. In each country the national malaria control programme provided the research team with a letter of approval, and supported the study as part of a routine programme evaluation.

Table 12: Interviews (participants) included by category, by country

	MALI	**MALAWI**	**KENYA**	**RWANDA**	**Total**
Facility	2 (9)	3 (3)	4 (6)	2 (5)	11 (23)
Sub-National Health office	1 (4)	1 (2)	1 (7)	2 (3)	5 (16)
National Malaria Control Unit	2 (2)	1 (2)	1 (6)	2 (2)	6 (12)
National Reproductive Health/MCH Unit	1 (1)	1 (1)	1 (1)	.5* (1)	3.5 (4)
National EPI Unit	-	1 (1)	1 (1)	.5* (1)	2.5 (3)
Logistics (National level)	-	1 (1)	-	3 (3)	4 (4)
Partner Organizations (National level)	1 (2)	3 (3)	1 (2)	1 (1)	6 (8)
Total	7 (18)	11 (13)	9 (23)	11 (16)	38 (70)

*One interview covering both reproductive health and EPI in Rwanda

5.4. Results

Based on the perceptions of the respondents, five thematic areas emerged as central in terms of operational barriers to continuous LLIN distribution in all four countries: 1) Quantification; 2) Logistics systems; 3) Stock-outs; 4) Training; and 5) Data Management. These replaced the *a priori* themes of policies and management; logistics; programme implementation and human resources; and data collection, management and use. Logistics and data management are both *a priori* and emergent themes, while stock-outs, training and quantification emerged as more narrowly focused topic areas of importance. These five thematic areas captured the weaknesses and challenges identified by respondents in all four countries. A summary of the findings across countries, by these five thematic areas, is presented in Table 13. Figure 17 describes the operational barriers, following the LLIN distribution path, as a cascade leading to stock-outs at the facility level.

Figure 17: Operational barriers leading to stock-outs and decrease confidence in services

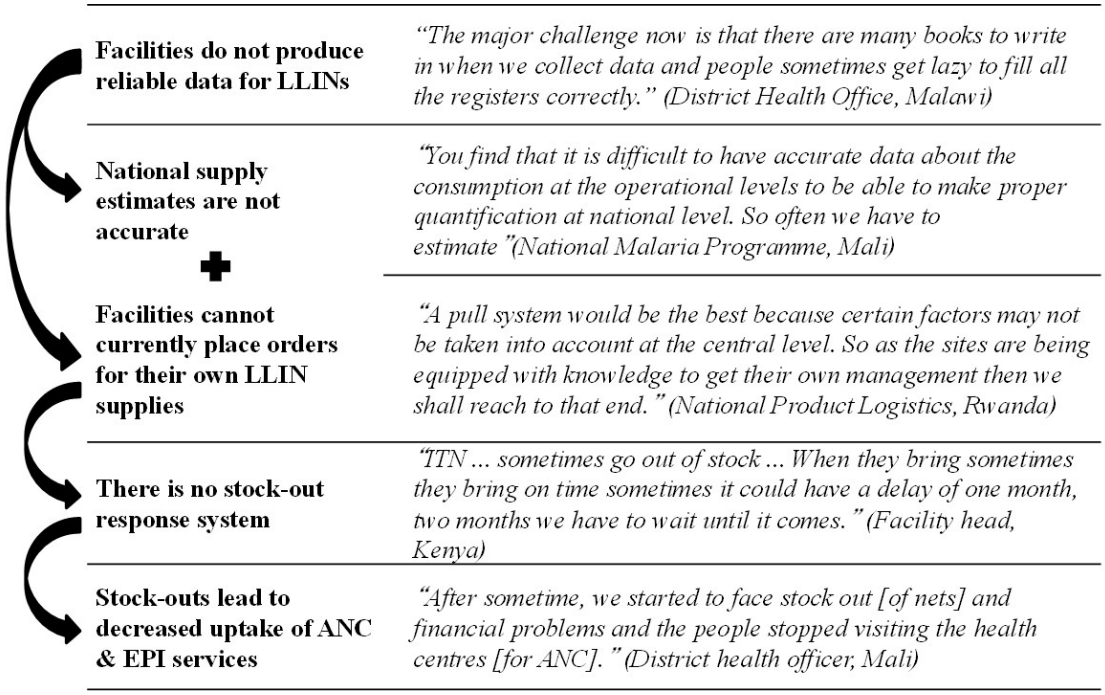


Table 13: Summary of findings, by thematic area

Thematic Area	Specific Area	Key Findings
Quantification		-All programmes conduct annual quantification exercises to produce supply needs - Both population estimates as well as facility consumption data are used to produce LLIN quantifications -Poor data quality at the facility level results in national-level estimations that may have errors
Logistics Systems	Distribution management	-LLIN distribution managed separately from other commodities -Ideal scenario is integrated distribution; practical solution is separate -Bulk of nets was not identified as a major challenge for distribution -Heavily led by partner organizations
	Supply and restock	- Each country had a different frequency of restock -Commodities with dedicated funding and distribution most reliable supply chain (e.g. HIV, EPI, LLIN) -Order placed primarily top-down "push" not bottom-up
Stock-outs	Occurrence	-All countries had reported stock-outs by facilities
	Remedy	-Make-shift stock-out corrections -No clear stock-out guidelines in any country
Training		- Lack of funding available -Focused on new staff
Data Management	Collection	-Overwhelming amount of registers and report forms for health workers to fill out at the facility level -Missing data were common in registers that were reviewed -Special LLIN distribution register produced by partner organizations
	Use	-Facilities rarely used data for progress tracking -National and sub-national programme staff used facility reported data -National malaria programme conducted surveys in addition to routine data to track programme impact

5.4.1. Quantification

In each country, the malaria control unit used population statistics (estimations of expected pregnancies and births) and facility consumption data (LLINs distributed to/from each facility) to produce a "quantification" – a plan for the quantity of LLINs needed in the next year. The quantification process in all four countries was managed at the national level with support from partner organizations, some input from sub-national level staff, but no direct input from facility staff. The national malaria programme managers in Kenya and Mali reported using primarily population statistics to estimate the LLINs needed, due to concerns about consumption data quality and completeness.

"A population grows, so we cannot use consumption data to go and say that this is now what is expected." (National Malaria Programme, Kenya)

"You find that it is difficult to have accurate data about the consumption at the operational levels to be able to make proper quantification at national level. So often we have to estimate… For example, we consider the percentage of pregnant women in the population and based on that we estimate the number of nets."(National Malaria Programme, Mali)

In Malawi and Rwanda, LLIN quantifications also used population estimates as the primary data source, but these estimates were adjusted using consumption data reported from facilities.

"Every quantification is based on all the methods so regardless you have 100% or 0% reporting you look at your population, you need to locate your consumption if you have any numbers. So any quantification cannot be based on one method only, you have to work with all the methodologies, provided you have the data" (Partner organization, Malawi)

5.4.2. Logistics systems

In all four countries, at the national level, the logistics system (the organization, management, and implementation of storage, transport and distribution) for routine LLINs was managed separately from that of other health service commodities with support from partner organizations. Health systems with dedicated funding and/or independent distribution, such as HIV services, LLINs, and vaccines, were identified by facility staff in the four countries as having the most reliable supply chains. Conversely, at the national and sub-national levels, and within partner organizations, staff felt that ideally LLIN would be managed and distributed by the government, as part of an integrated supply system for health commodities. However, given the resources and capacity currently available, and the experience and expertise brought by partner organizations, both national level government and partner officials stated that at the current time separate systems were more functional.

"At the moment we ... are running a parallel supply chain. In other words we have got a parallel system where we do storage and distribution. In an ideal situation all storage

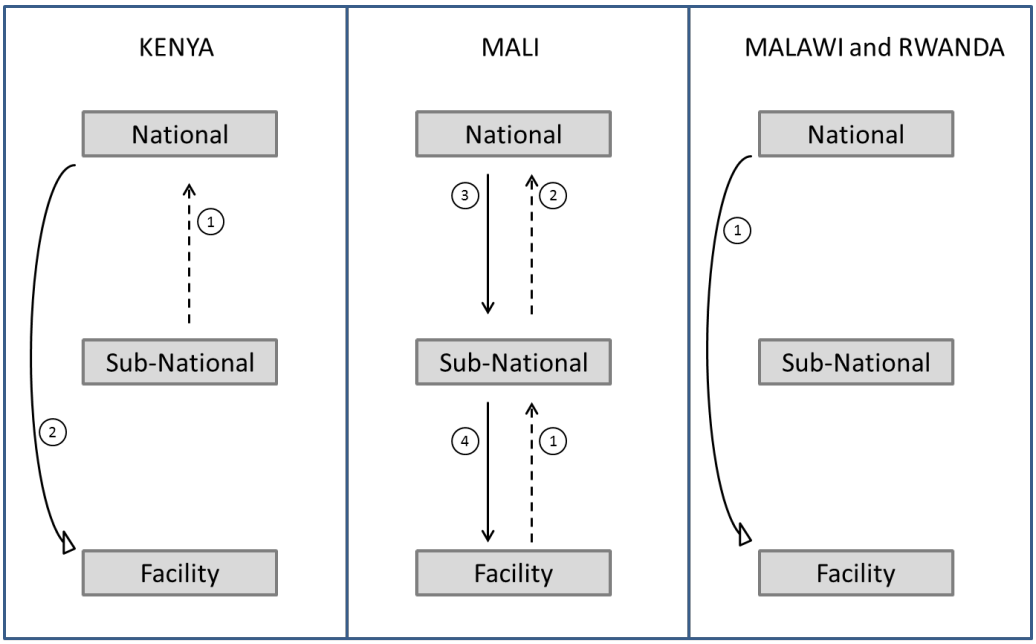
and distribution will go through the national system but in the country there are several similar supply chains" (Partner Organization, Malawi).

Storage space for LLINs at the national level, directly after shipments were received from suppliers, was presented as a problem when international shipments came in large amounts.

"Sometimes the nets come at once and we find ourselves running up and down to find warehouses to stock them ... Keeping nets for a long period does not happen often but in the past we have experienced situation where the number of nets was higher than what our storage capacity could accommodate." (National Health Product Logistics, Rwanda)

The frequency of resupply of LLINs to local facilities varied between countries. There was one supply of LLINs per year in Rwanda, two per year in Mali, and four per year in Kenya. In Malawi, facilities were re-supplied monthly. The resupply system was different in each country, illustrated in Figure 18. With the exception of Mali, the LLIN supply chain largely skipped over the sub-national level, providing LLINs to facilities directly from the national level. The supply chain in Mali and Kenya included stock requests from lower levels, while Malawi and Rwanda provided LLINs to facilities based on national supply plans. In each country, however, the sub-national level was informed of the LLIN shipments being provided to facilities. No one system created a more consistent supply of LLINs at the facility level than any other.

Figure 18: Supply order and fill process in each country



Kenya: 1) Sub-county health office places order to national programme on behalf of facilities, based on sub-country quantification developed by the sub-county health office with support from partners; 2) national programme fills order to facilities from regional storage warehouses
Mali: 1) Facilities place request order to district based on consumption; 2) district collates all facility request, and places request to national programme; 3) national programme "corrects" order based on LLIN availability and its own quantification estimates and fills order to the district; 4) district adjusts and fills facility orders based on available supplies.
Malawi and Rwanda: 1) Facilities supplied based on national distribution plan; Malawi uses regional storage space to keep LLIN supplies between national distributions.

In Rwanda and Malawi, health facility staff expressed concerns about the management of stock and of storage space for LLINs once LLIN stock reach the facility. In Kenya and Malawi, LLINs were usually stored in the same consulting room where ANC services were provided. In larger district facilities in Malawi, the main stock of LLINs was kept in the pharmacy stores, and smaller quantities were kept in service delivery rooms. In Rwanda and Mali, LLINs were kept in a storage space that was either dedicated to LLINs alone, or shared with a variety of other commodities – in Mali these facilities were kept locked due to LLIN security concerns. In facilities in all four countries, the storage location of LLINs seemed to be dictated by the available space, layout of the facility, and convenience for health workers. Although storage space was frequently cited as an inconvenience, it was never mentioned as a cause of service failure.

In all four countries, facilities were not able to place orders for LLIN supplies, and would, instead, wait for shipments from the national level.

"We are able to know that in this year we are going to distribute so many nets in these health facilities. So from this, we are able to form itineraries that will be able to fit, and we are able to achieve the objective of distributing the nets ... We have our work plans, based on the national Malaria guideline. Like, if these nets are required to be given to a certain facility, we are able to work within that and be able to deliver the nets within the stipulated time." (Partner Organization, Kenya)

In all four countries respondents at all levels expressed an interest in developing and/or strengthening a system whereby facilities can place orders for more LLINs, based on stock levels and need.

"A pull system would be the best because certain factors may not be taken into account at the central level. So as the sites are being equipped with knowledge to get their own management then we shall reach to that end." (National Health Product Logistics, Rwanda)

In Kenya, the LLIN system was slowly transitioning to one in which lower levels submit orders based on need. This system had been rolled out and implemented down to the sub-county (sub-national level) at the time of the evaluation, and there were plans to extend it to facility level. In Malawi and Mali, the staff at the national level was less confident about facilities' ability to order supplies for restock consistently and accurately.

"Since [facilities] are not able to quantify properly the need for the nets, we rely on statistics and hypothesis based on the population."(National Malaria Programme, Mali)

5.4.3. Stock-outs

In all four countries, staff at facilities described experiencing stock-outs with no formal system to rectify this. As a result, staff at facilities reported using informal methods with mixed outcomes. In Rwanda, LLIN stock-cards were used to track stock levels, which were reported to the district. At the district, the stock levels were entered in the electronic information system. When stock-outs occurred they were reported through this same system, and could be seen at the national level. In Malawi, facilities reported waiting for more supplies of LLINs during stock-outs, rather than actively seeking re-stock from national level, although in some cases, there was an informal stock-sharing system with facilities nearby when there were stock-outs. In Kenya, facilities reported having stock-outs generally lasting no more than one week before re-

supply, with a maximum wait-time of three months. In Kenya, facilities would call the partner organization contact and/or sub-national malaria focal person directly to report stock-outs.

> *"[ITN supply] has been quite irregular… When they come they have to be supplying a whole area, so sometimes it could take three months, four months; we can go even three months on end without supplies. So that one is completely out of our control." (Health Facility, Kenya)*

> *"Sometimes we face stock outs and we are not able to give nets for example now we do not have any so people go home without nets." (Health Facility, Malawi)*

> *"After sometime, we started to face stock out [of nets] and financial problems and the people stopped visiting the health centres [for ANC]…That is, to me, the only reason that negatively impacts the implementation of these policies." (District Health Office, Mali)*

5.4.4. Training

Staff at health facilities reported receiving training for continuous LLIN distribution less frequently than for other programmes and tasks. For example, staff described annual trainings on intermittent preventive treatment for malaria in pregnancy, and for vaccination services, in all countries. At national and sub-national levels, across all four countries, staff expressed concern that there was not enough funding available for the training that was planned and needed. National malaria programme staff and partner organizations reported limiting LLIN trainings to new staff, instead of including all staff, as a way to deal with limited funding and high staff turnover.

> *"If we have funds from donors we organize trainings for the staff but for the past two years' trainings have been through the [National] Malaria Control Programme. They provide training about malaria in general. We were supposed to have trainings about the ITN distribution … but we did not." (District Health Office, Malawi)*

> *"There is an issue of staff turnover. The staff you train this year is not the staff you find next year so there is always a need for more trainings ... When someone is new, we have to train the person and we do not always have funds to do that." (National Health Product Logistics, Rwanda)*

5.4.5. Data management

Across countries, health workers at the facility level reported an overwhelming number of registers and reports to fill as part of the job, which captured all services delivered throughout the health centers. In all four countries, when viewing registers, there were examples of missing data, inaccurate entries and unorganized paperwork. In many cases a report format or tool was described in an interview but was unable to be located when requested. While many registers and reporting forms were official government forms, some additional report forms were produced by partner organizations for monitoring the programmes that they sponsored. In one facility visited in Kenya, the head of the facility listed 23 separate reports that were required every month.

> *"The major challenge now is that there are many books to write in when we collect data and people sometimes get lazy to fill all the registers correctly." (District Health Office, Malawi)*

> *"A challenge often at facility level is making sure that these two registers speak to one another because at times you might find that one is fully filled, so because they know that [we] will use that net pack record, because that is the one we use for consumption data and so on, sometimes they forget to fill in the net details on the children CWC register and on the mother's register as well." (Partner Organization, Kenya)*

In Kenya, Malawi and Rwanda, electronic health information systems were available at the national level, and in some regions and districts, but not at the facility level. The number of LLINs distributed via ANC and EPI was included as an indicator in these systems in all three countries. Other indicators that were of interest to national level staff were stock shortages/stock-outs and shipments, though these data were not available in the systems at the time of the assessment. At the sub-national and national level in all countries, regardless of the presence of electronic record systems, there was distrust in the information being captured and produced at the health facility level. This was expressed in both countries that did and did not use facility consumption data for quantification. Sub-national staff reported contacting health facilities to verify and correct inaccurate and incomplete reports, but the final output was still not seen as a reliable representation of service delivery.

> *"We currently face stock out problems because health workers have difficulties in measuring their monthly consumption. The ideal scenario would be if they could*

accurately estimate the monthly consumption so they order consequently." (National Malaria Programme, Mali)

To track programme performance, programme staff from EPI and ANC at the national level commonly reported using routine facility-based service delivery data. By contrast, in all four countries, it was far more common for malaria programme staff to identify surveys as the main data source for assessing national LLIN programme success.

"We ... do surveys or investigation to know how people sleep under a net." (National Malaria Programme, Mali)

"Annually we are conducting the survey just to assess how much we have achieved in terms of coverage" (National Malaria Programme, Malawi)

When asked directly, national malaria programme staff did confirm that they also use the routine LLIN distribution data collected at facilities to track the progress made in LLIN distribution.

At the facility level, staff rarely reported tracking their own progress using the service delivery data they collected. More often, health facility staff described collecting data for the purpose of reporting to the higher levels of the health system. The main exception to this was for non-LLIN programmes, when the facility was responsible for placing orders for a given commodity, such as vaccines or drugs.

5.5. Discussion

In all four countries respondents at the facility level described an inconsistent supply of LLINs for continuous distribution, leading to stock-outs. As a result, the malaria programme in each country was unable to provide LLINs to the women and children attending ANC and EPI, when facility level stock-outs occurred. This unreliable supply of LLINs may also decrease the communities' confidence in, and uptake of, ANC and EPI services (Figure 17).

The main factor identified as contributing to stock-outs at the facility level was the facilities lack of involvement in supply decisions. Specifically, facilities did not participate in quantification exercises, were not given the authority to place regular orders for LLIN resupply, and did not have a system in place to report and remedy stock-outs when they occurred. A key issue underlying these constraints was that facility data was not deemed reliable by the higher service levels.

These findings suggest that, a) facility-led resupply systems allowing local health facilities to request additional LLINs, b) improved data collection and management during service delivery, and data use for quantification, and c) the development of stock-out response systems, can improve the reliability and availability of LLIN stock at the facility level.

Malaria programme staff at the national and sub-national level expressed an interest in having facility level staff place orders for LLIN resupplies as needed. Despite this interest, a system of this nature had not been implemented in any of the countries at the time of this assessment. While the need for facility-led resupply has not been identified in previous LLIN research, it has been a finding in broader supply-chain studies. In 2001, a review of the Kenya medical supply agency (KEMSA) identified some similar areas for improvement including training, data management, and a feedback mechanism between facilities and national level programmes.[201] A study in Tanzania evaluated the impact of an integrated logistics system where facilities were given the responsibility of quantifying consumption and placing orders for supplies.[202] While there was an improvement in accountability of supplies in some commodity chains, the system did not fix the concerns of poor data and monitoring all together.[202] Both Rwanda and Malawi have recently been involved in a project to strengthen community health supply chains, focusing on antibiotics, ACT, ARTs, and ORS.[203] These evaluations both identified the need for products to be ordered based on facility need, through clear procedures.[203] They also noted the need for strong data management and use to ensure accurate information is available to inform management decisions.[203]

These studies have recommended improved reliability of data, produced by facilities during service delivery, in conjunction with facility-led ordering system. This pairing helps national programmes to have confidence in orders placed at the facility level. Likewise, implementing partners and funding agencies have produced reports and guidelines on improving the supply chain for malaria programmes, which often recommend improving quality data management and use, especially for quantification.[204–206] Surveys were mentioned in all four countries as the primary tool for measuring LLIN programme performance. While surveys are the best way of evaluating LLIN use within communities, routine data collected at the time of service delivery are an untapped resource from which malaria programmes can benefit. Service delivery data has been collected, used and trusted by other programmes (such as vaccines), and could be an important source of information for malaria control programmes.

A better understanding of programme performance could be gained by ensuring LLIN distribution is routinely tracked as a key indicator and compared to ANC and EPI routine

service delivery numbers. Similarly, an analysis of integrated community case management in 18 African countries also found that programmes would benefit from taking advantage of routine data for monitoring.[207] That analysis also recommended strengthened data use and response, and triangulation of routine data, as ways to improve the use of routine service delivery data.[207]

Improved data collection and use can increase confidence in facilities' ability to place orders, but it may not stop stock-outs from occurring all together. The availability of electronic health information systems did not improve stock-out response time in the three countries where they were present, though these systems were not available at the facility level at the time of the assessment. Likewise, different frequencies of restock, from monthly to yearly, did not prevent stock-outs experienced in any of the four countries. As a result, a well-developed and standardized stock-out response system is necessary to ensure a continuous supply of LLINs at the facility level.

In all four countries, concerns were expressed about the lack of training specifically for the continuous distribution of LLINs. To develop a facility-led resupply system, and foster confidence in that system for staff at the higher levels, more emphasis on training could be made, especially around data collection and use. Trainings could be conducted as stand-alone sessions, as part of ANC or EPI trainings, or as part of broader malaria programme trainings.

Logistics challenges and stock-outs have been identified in LLIN research before. However, these concerns are often voiced in the discussion section of studies, while the main focus of the research is cost effectiveness, feasibility and/or scalability.[85,98,208,209] In one study in Ghana, the transportation aspect of the supply chain, specifically, was seen as a contributor to stock-outs and supply shortages, which was not identified as a specific barrier in the four countries included in this study.[104] Beyond LLIN distribution, supply chain management has been a major focus of health systems research, for essential medicines, health commodities and vaccinations.[203,210–214]

The space nets take up is not trivial at any level of service delivery. In a study in Kenya, one district did not have a supply of nets because the bulk of the nets was underestimated, and so the space required to transport them was not available.[80] It is interesting to note that in this study, net-volume was mentioned as a burden when discussing storage, but was not brought up as a challenge when discussing logistics transportation in any of the four countries. While

the reason for this is unknown – it may be because it is obvious, or alternatively because it is not actually a concern in these countries – it is worth noting that it was not mentioned.

There are several limitations of this study. Given the rapid nature of the project only 2-4 facilities were included, and 7-11 interviews were conducted with a total of 13-23 participants per country. As a result of the small numbers of facilities, it was not possible to include facilities that were both very strong and very weak in terms of service delivery. Therefore, in line with the intention of the research, the national malaria programmes each made an effort to select facilities that were "average performing" in terms of service delivery, and were "typical" in terms of access and distance to major cities. It was not possible to compare these facilities to those not chosen, so there is potential bias in the facility selection. While the findings represent the experiences in these facilities, the issues for facilities at the ends of the spectrum (very high or low performing) may be different. In two cases, originally selected facilities were replaced due to lack of access, as a result of flooding in Rwanda, and time constrains due to heavy work load in Malawi. Selection bias may have been introduced during the reselection process. Because of the small number of interviewees per country, this project may not have captured the total breadth of experiences in each country. On most topics, however, common experiences were recorded and reiterated across countries and interviews, suggesting that most important challenges were uncovered.

In one country, despite the intended protocol, a senior malaria programme staff member attended facility level interviews, which may have resulted in facility staff feeling less comfortable to speak freely. Likewise, in larger group interviews, especially in those at facilities where supervisors and general staff participated at the same time, there may have been a tendency for one person to lead in the answers. While questions were targeting different staff members, the responses were not always even. Experiences of divergent activities or criticism of policies or systems may have been voiced less frequently in these environments. Despite these limitations, valuable information was identified through interviews in all four countries, leading to a greater understanding of the operational challenges associated with the continuous distribution of LLINs.

5.6. Conclusions

Each country is implementing a well-developed and planned LLIN distribution programme with clearly structured and presented policies and guidelines that have been communicated effectively at every level. While each country has created a unique and different policy and

implementation plan, with differences in re-supply frequency and use of electronic databases, major cross cutting challenges can be seen as 1) facilities' lack of involvement in the order and resupply process, and 2) the lack of structures in place to effectively and promptly respond to stock-outs at the facility level. These are undercut by a distrust in facility level data collected and reported to national programmes. These may also be challenges faced by other African countries implementing continuous LLIN distribution that were not included in this evaluation. Addressing these challenges has the potential to create a consistent and uninterrupted supply of LLINs, which is ultimately essential to make this programme truly a routine service.

Though it was not addressed in this research, the cost associated with improving these systems cannot be overlooked. Creating facility-led re-supply of LLINs will have financial implications which must be addressed in order to identify and implement cost-effective approaches and make any solution sustainable. One financial concern may be related to ensuring a "buffer stock" is maintained to resupply facilities when requested. As with all health commodities supplied continuously, the availability of stock, in country, to meet demand, is an essential part of routine service delivery. This would not require the purchase of additional LLINs, but rather, would require a consistent supply and storage of nets in country before they are needed. The storage facilities and stock already exist in country, but are not currently used as buffer stock, and thus not organized accordingly. Planning for and maintaining a buffer stock of LLINs will be an essential part of ensuring a truly continuous routine distribution of LLINs.

While the national level in all the countries did not see an immediate benefit to integrating the LLIN supply-chain with other health commodities, it may be an area that warrants further investigation. Facility level staff expressed an interest in an integrated system to improve service delivery. If implemented effectively, an integrated system may also provide cost savings due to shared services between programmes.

This study did identify specific operational barriers to the continuous distribution of LLINs leading to facility level stock-outs. Focusing on these barriers as priority areas for development and improvement can assist national programmes to identify specific solutions and tailored approaches that will work best in the unique context of each country.

5.7. Competing interests

The authors declare that they have no competing interests.

5.8. Authors' contributions

Conceived and designed the study: KTN; Contributed to design and tools: JW, JL, HK, ML; Supported site and respondent selection: WE, DK, CK; Conducted interviews: KTN, YC; Analysed the data: KTN; Wrote paper: KTN; Critical review of analysis and interpretations: JL, JW; Editorial inputs: JL, JW, HK, ML, WE, DK, CK, YC. All authors read and approved the final manuscript.

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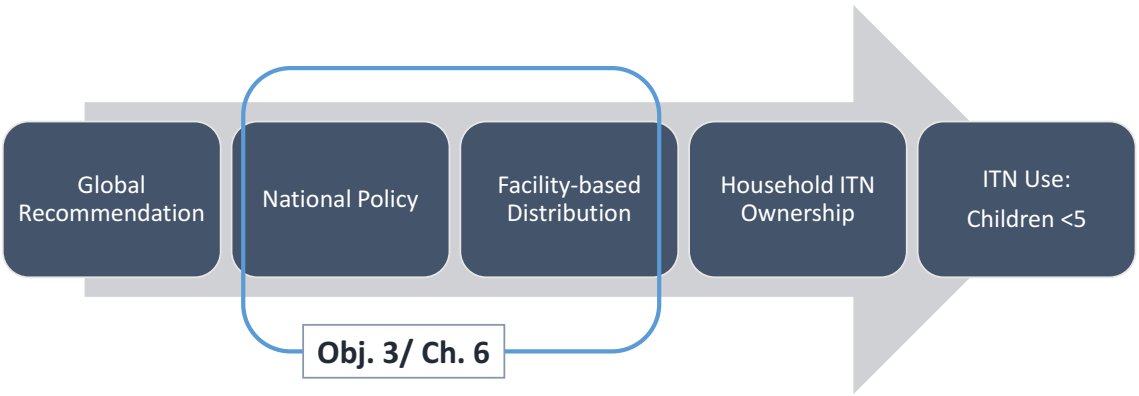
CHAPTER 6: THE RELATIVE ROLES OF ANC AND EPI IN THE CONTINUOUS DISTRIBUTION OF LLINS: A QUALITATIVE STUDY IN FOUR COUNTRIES

Chapter 6 addresses the third objective of this thesis, to evaluate routine ITN distribution via ANC and EPI programmes and describe the differences between ANC and EPI as platforms for LLIN distribution, to learn from the strengths and weaknesses of these programmes.

This chapter takes a closer look at the difference in the availability ratios for ANC and EPI-based ITN distribution, reported in chapter 4. While chapter 5 identified operational barriers that would apply to both ANC and EPI-based distribution programmes, this chapter focuses on the differences between the two programmes that might help or hinder integrated ITN distribution. Like chapter 5, this chapter also looks at the national policies and implementation in four African countries (Figure 19).

Figure 19: Process elements included in Chapter 6



The findings presented in this chapter are the result of further analysis using the same qualitative assessment presented in Chapter 5. The specific topic presented in this chapter was not included in the deliverable analysis for VectorWorks, USAID and PMI. This was a complementary investigation conducted using the same qualitative data points.

This chapter includes also includes the LSHTM Cover Sheet for research papers included in a research thesis.

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Student Signature: [redacted] **Date:** __20/03/2017____

Supervisor Signature: [redacted] **Date:** __20/03/2017____

The relative roles of ANC and EPI in the continuous distribution of LLINs: a qualitative study in four countries

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6.1. Abstract

Background

The continuous distribution of Long-Lasting Insecticidal Nets (LLINs) for malaria prevention, through Antenatal care (ANC) and the Expanded Programme on Immunization (EPI), is recommended by the WHO to improve and maintain LLIN coverage. Despite these recommendations, little is known about the relative strengths and weaknesses of ANC and EPI-based LLIN distribution. This study aimed to explore and compare the roles of ANC and EPI for LLIN distribution in four African countries.

Methods

In a qualitative evaluation of continuous distribution through ANC and EPI, semi-structured, individual and group interviews were conducted in Kenya, Malawi, Mali, and Rwanda. Respondents included national, sub-national, and facility-level health staff, and were selected to capture a range of roles related to malaria, ANC and EPI programmes. Policies, guidelines, and data collection tools were reviewed as a means of triangulation to assess the structure of LLIN distribution, and the methods of data collection and reporting for malaria, ANC and EPI programmes.

Results

In the four countries visited, distribution of LLINs was more effectively integrated through ANC than through EPI because of a) stronger linkages and involvement between malaria and reproductive health programmes, as compared to malaria and EPI, and b) more complete programme monitoring for ANC-based distribution, compared to EPI-based distribution.

Conclusions

Opportunities for improving the distribution of LLINs through these channels exist, especially in the case of EPI. For both ANC and EPI, integrated distribution of LLINs has the potential to act as an incentive, improving the already strong coverage of both these essential services. The collection and reporting of data on LLINs distributed through ANC and EPI can provide insight into the performance of LLIN distribution within these programmes. Greater attention to data collection and use, by both the global malaria community, and the integrated programmes, can improve this distribution channels strength and effectiveness.

6.2. Key Messages

- The planning and management of LLIN distribution was strengthened by active involvement from ANC programme staff, but rarely included EPI programme staff, reflecting the fact that more nets are distributed through ANC than EPI
- Data on the numbers of nets provided at ANC and EPI clinics is collected by health workers, but is not used by malaria or EPI programmes to monitor operational performance. This results in the loss of critical information, and a missed opportunity to measure process indicators.
- LLINs are a potential incentive for programme attendance, and so improving the performance of LLIN distribution through ANC and EPI is likely to improve ANC and EPI coverage

6.3. Background

Long lasting insecticidal nets (LLINs) are the mainstay of vector control for malaria prevention. The WHO recommends universal coverage, defined as one LLIN for every two people within a household, for malaria endemic countries and regions.[68] Eighty-eight countries, 39 in Africa, distribute Long Lasting Insecticidal Nets (LLINs) free of charge.[1] The

main channel for LLIN distribution since the early 2000s has been mass campaigns, thanks to successful trials[23] and international funding.[28] Since 2007 the WHO has produced recommendations and guidelines, supported by Roll Back Malaria, emphasising the continuous distribution of LLINs through ante-natal clinics (ANC) and the Expanded Programme on Immunisation (EPI), to complement campaigns and improve coverage.[65,66,68,194] The recommendations suggest, "giving higher priority to routine services, such as ANC and EPI, as a means of LLIN distribution to sustain Universal Coverage."[65] They further state that "continuous distribution channels should be functional before, during, and after the mass distribution campaigns to avoid any gap in universal access to LLINs."[68]

The WHO and UNICEF developed the Global Immunization Vision and Strategy (GIVS) in 2005 which promoted the integration of EPI with maternal and child health programmes to improve community demand and coverage of services.[31] In May 2012, the Global Vaccine Action Plan (GVAP) framework was endorsed at the World Health Assembly.[33,215] One of the six GVAP principles is integration, stating: "strong immunization systems, as part of broader health systems and closely coordinated with other primary health care delivery programmes, are essential for achieving immunization goals."[33,215]

In 2006, the Partnership for Maternal Neonatal and Child Health (PMNCH) produced a document entitled, Opportunities for Africa's Newborns.[37] Among other topics, this document describes the essential services and benefits included in ANC services for maternal health and newborn outcomes. PMNCH describes ANC within this guideline as "a vehicle for multiple interventions and programmes."[37] PMNCH further promotes the distribution of ITNs, specifically, along with IPTp to prevent malaria during pregnancy.[37]

International support for integration, combined with a growing body of research highlighting the financial, service delivery and coverage benefits of integrated maternal and child health services, has led to political commitment from national programme leaders. As a result, 38 countries in Africa have implemented integrated LLIN distribution through ANC and/or EPI.[216]

Despite the international and national interest in integration, the implementation of continuously distributed LLINs has been sub-optimal, particularly through EPI. The *availability ratios* of continuous distribution, defined as the number of women attending

ANC at least once, or children attending EPI for DTP1 vaccination, divided by the number of LLINs allocated for distribution in that respective channel in the same time period, were 55% and 34%, respectively.[1,216] Research looking at the distribution of LLINs through ANC has largely focused on feasibility, cost per net delivered, and modelling the potential coverage that could be achieved through improved continuous distribution.[73,80,84,86,98,101,102,106] Fewer studies have considered LLIN distribution through EPI, and have focused on feasibility,[48] time of delivery,[105] and health worker perceptions.[60] These studies have generated positive results for both ITN delivery and the programmes within which they are delivered.

Given the growing number of countries integrating these services, this study aimed to qualitatively assess and compare the performance of the continuous distribution of LLINs through ANC and EPI services in four African countries, and identify challenges and areas for improvement which can help to strengthen integrated service delivery.

6.4. Methods

A qualitative evaluation of continuous LLIN distribution programmes was conducted between March and May of 2014 with participants in Kenya (n=23), Malawi (n=13), Mali (n=18) and Rwanda (n=16), as shown in Table 14. The evaluation used a Rapid Assessment Process (RAP), including semi-structured interviews and document review, to identify evidence for decision-making within a limited time frame.[151] The countries were selected in order to cover a broad range of settings in Africa. In consultation with USAID/PMI the countries were chosen from the Presidents Malaria Initiative (PMI) countries, to include countries from Anglophone and Francophone Africa, with a variety of malaria transmission settings, and with a range of ANC, EPI, and LLIN coverage levels.

Facilities were purposively selected in consultation with the Ministry of Health (MOH) in each country as examples of facilities providing the lowest level of community health care, outpatient and maternity services (Kenya: level 3; Malawi: Health Centre; Mali: CSCOM; and Rwanda: Health Centre), and being non-urban, away from major roads, in malaria endemic regions, and average-performing in terms of health service delivery. In total, two health facilities from Mali in Koulikoro region, three facilities from Malawi from all three regions, three facilities from Rwanda in the Northern and Southern Provinces, and four facilities from Kenya in Western and Nyanza province were included.

Table 14: Interviews (number of interviewees) by country and by staff category

	MALI	MALAWI	KENYA	RWANDA	Total
Facility (Facility heads, staff involved in ANC and EPI delivery)	2 (9)	3 (3)	4 (6)	2 (5)	11 (23)
Sub-National Health office (Staff overseeing malaria, ANC, EPI, and M&E)	1 (4)	1 (2)	1 (7)	2 (3)	5 (16)
National Malaria Control Unit	2 (2)	1 (2)	1 (6)	2 (2)	6 (12)
National Reproductive Health/MCH Unit	1 (1)	1 (1)	1 (1)	.5* (1)	3.5 (4)
National EPI Unit	-	1 (1)	1 (1)	.5* (1)	2.5 (3)
National Logistics (supporting LLIN, vaccine, and general commodity distribution)	-	1 (1)	-	3 (3)	4 (4)
Partner Organizations – national level (supporting LLIN programs, reproductive health)	1 (2)	3 (3)	1 (2)	1 (1)	6 (8)
Total	7 (18)	11 (13)	9 (23)	11 (16)	38 (70)

*Combined reproductive health and EPI interview in Rwanda

Interviews were conducted with key informants from the national, sub-national, and facility levels. Before each interview began, the aims of the project were explained, information sheets were provided to each participant and written consent was obtained. Respondents were purposively selected, by the research team with advice from national programme staff, to capture diverse roles in the malaria, ANC and EPI programmes (Table 14). The interview guide was structured around the WHO "Six building blocks for health system strengthening": Service Delivery; Health Workforce; Information; Medical Products, Vaccines, and Technology; Financing; and Leadership and Governance, to ensure that these core aspects of the health system were captured.[166] Interviews were conducted by a team of two researchers, with one respondent or in small groups, in French or English, depending on the availability and comfort of the respondents. In each case one researcher conducted the interview while the other took notes and identified areas where more information was needed. Interviews were recorded, transcribed, translated to English if conducted in French, and analysed using Nvivo10. The analysis began with broad themes related to the WHO Six Building Blocks for Health System Strengthening. The analysis was done in two parts. The first identified the operational challenges for continuous

distribution of LLINs.[197] The second analysis, presented here, identified emergent themes where differences were seen in LLIN distribution through ANC and EPI. The protocol was reviewed and approved by the authors' institutes.

6.5. Results

The analysis identified five broad areas where the differences in ANC and EPI based LLIN distribution were most pronounced: policy and management, service delivery, non-compliance with policy, supervision, and data collection and use. The results are structured in these five broad areas. A summary comparison of the ANC and EPI systems, showing important specific differences, is presented in Table 15.

Table 15: Summary of findings of LLIN distribution through ANC compared to EPI

Thematic Area			ANC		EPI
Policy and Management	Global Recommendation	✓ ✓	ANC recommended as a platform for LLIN distribution Clear recommendation from WHO and Roll Back Malaria on the timing of LLIN distribution within ANC (first visit)	✓ ×	EPI recommended as a platform for LLIN distribution No international timing recommendations for EPI based distribution
	National Policy	✓	Both malaria and reproductive health programme policies include LLIN distribution to pregnant women	×	EPI policies include only antigen specific guidelines and do not include the distribution of LLINs to infants
	Management	✓	Both Malaria and Reproductive health programmes oversee the implementation of LLIN distribution	×	The EPI programme is not involved in the management of LLIN distribution to infants
Service Delivery	Distribution timing		All countries used first ANC visit, in line with global recommendations In Rwanda, the national policy only distributed LLINs to first time mothers (primigravid) rather than to all pregnant women		Timing varied by country In Malawi, if the point of distribution is missed (at delivery in maternity ward) there is no clear system to identify and provide LLINs to infants at the next point of contact (EPI).
	LLIN as incentive	✓ ×	Cited as a positive incentive for attendance Concern that LLIN stock-shortages could negatively impact attendance	✓ ×	Cited as a positive incentive for attendance Concern that LLIN stock-shortages could negatively impact attendance
Supervision	Supervision	✓	Malaria and Reproductive health programmes jointly supervises ANC-based LLIN activities	×	Only the Malaria programme supervises the LLINs distributed to infants. The EPI programme is not involved
Data collection and use	Data collection	✓	Both LLIN and ANC registers included LLINs distributed to pregnant women and are consistently used	×	LLIN register included data on LLINs distributed to infants. EPI tools rarely included LLIN, and were not used when included
	Data reporting and use	✓	ANC-based LLINs reported as part of ANC service reports for programme monitoring from facilities to higher levels	×	EPI-based LLINs not reported as part of EPI service delivery and programme monitoring

6.5.1. Policy and Management

Policy

In all four countries the national malaria programme produced policy guidelines for the continuous distribution of LLINs to pregnant women during ANC and to infants during EPI (or new-born services in the maternity ward, in the case of Malawi). The ANC-distribution policy in Kenya, Malawi, and Mali reflected the global recommendations to provide an LLIN

during the first ANC visit for all pregnant women.[65,68] Rwanda also used the first ANC visit for LLIN distribution, but following new national guidelines implemented in 2012, limits LLIN distribution to primigravid women. National malaria program staff in Rwanda explained that this choice was made because of the high coverage achieved through campaigns, leading to an ANC policy which only targets "new households".

> *"We only give to the first time pregnancies because we assume that it is a new couple therefore a new household." (National Malaria Programme, Rwanda)*

There is no global recommendation for the timing of LLIN distribution during EPI, i.e. when in the overall infant immunization schedule the LLIN should be given.[65,68] Policy on this question differed in the four countries: at birth in Malawi; at first immunization visit in Kenya (which could be at birth or after); and at nine months of age, with measles vaccination and the completion of the immunization schedule in Mali and Rwanda (Table 16).

Quantification

As part of an annual planning process, each programme, in each country, produced a separate quantification to estimate the supplies needed for the upcoming year. National MOH staff reported consulting experts in other programmes for essential information used to inform quantification, (such as expected pregnancies or births) but each exercise was produced independently. National logistics staff in Rwanda described upcoming plans to integrate the quantification exercise, and in Kenya EPI staff expressed an interest in integrated quantification to save both cost and time.

> *"We do not have the … integration of the quantification. We can do an integrated one so that we can have one for all commodities because up to now we have every division doing it separately, but they involve all other technical staff. And this will be achieved very soon as it is one of the program objectives ... established two years ago, so we are building it now." (National Commodity Logistics, Rwanda)*

> *"Well, you'll find out that ... the malaria program will do their own quantification, as we do our own quantification. I think it would also be time-saving, more cost-effective if we did it together with that broader integration. But each unit does its own quantification." (National EPI Programme, Kenya)*

Management

In all four countries the national ANC/maternal health department staff within the MOH frequently reported being involved in the management of the LLIN distribution programme. By comparison, involvement with LLIN programming was rarely reported by staff in the EPI departments. The national maternal health department of the MOH in each country had ANC policies and guidelines which included the prevention of malaria in pregnancy. These guidelines included the use of LLINs during pregnancy and infancy.

> *"For antenatal care . . . when a pregnant woman comes, we make sure that she receives the tetanus vaccine, mosquito net, and we want to make sure that she has medical cover . . . and also make sure that women receive care at the community level. We want to integrate all those components so that when a pregnant woman comes she receives a full package." (National MCH Programme, Rwanda)*

> *"Pregnant women and children below 5yrs should sleep under ITNs/LLINs. These groups are the most vulnerable to infections" (Community Reproductive Health Package for Service Providers [document], MOH Kenya)*

By contrast, the EPI department policies and guidelines in each country described only the specific requirements for each antigen in the vaccine schedule. LLINs for malaria prevention, along with any other non-vaccine child health interventions, were not mentioned in any of the EPI policies and guidelines reviewed.

The malaria control programmes reported coordinating with the maternal health/reproductive health programmes in the development of policies and implementation of the ANC-based LLIN distribution, specifically around health worker guidelines and practice in all four countries. Likewise, the reproductive health units in each country reported working with the malaria units on issues of malaria in pregnancy.

> *"As a programme we have also tried to strengthen collaboration with other programs ... we are working together [with] antenatal care. From the start of planning to the implementation up to the level of monitoring, we are working hand in hand." (National Malaria Programme, Malawi)*

The EPI programme staff did not report direct involvement in the policy or management of LLIN distribution in any of the countries. In Rwanda both ANC and EPI fell under a

department of Maternal and Child Health, leading to better EPI integration with Malaria, as compared to the other three countries. In Malawi and Kenya, LLINs for continuous distribution were referred to as "ANC nets" as a short-hand for LLINs distributed through both ANC and EPI. In all four countries, when asked directly, the malaria unit reported an interest in working more closely with EPI (or child health) to implement the EPI-based LLIN distribution. The EPI programmes were supportive of integration in theory but were less involved with the LLIN programme and, with the exception of Rwanda, less aware of the policies. When discussing integration, malaria and LLINs were not mentioned by EPI respondents until these specific topics were introduced by interviewers.

> *"The [EPI] policy is basically specific to antigen. However, we advocate for integration of immunization services with other health services... We would want to integrate with [other services] such that... we can... immunize during the activities. Likewise, we also allow other programmes to ride on our activities. Because we believe, the more integrated that we are, the more we are able to put our services easily across the board." (National EPI Programme, Kenya)*

Table 16: Continuous LLIN distribution policies and programme coverage

	Kenya	Malawi	Mali	Rwanda
ANC Integration policy	ANC first contact	ANC first contact	ANC first contact	Primigravid ANC first contact*
EPI Integration policy	BCG	At birth†	9 months	9 months
ANC coverage (year)‡	88.5%	95.6%	70.8	97.1%
EPI coverage**	84%	89%	76%	99%
LLIN population access††	76%	76%	51%	57%

* Rwanda policy restricted to first time mothers
† Malawi policy integrates with delivery services, not EPI services
‡ WHO World Statistics Report 2014, Global Health Observatory Data [217]
** DTP3 coverage - WHO official estimate, 2013
†† LLIN access (proportion of the population for whom an LLIN is available for use in the household) from modelled data presented in the World Malaria Report 2014[10]

6.5.2. Service Delivery

In all four countries staff at all levels explained that while programmes work independently at the high levels, there was greater integration of service delivery at the facility level. National staff in both EPI and malaria programmes often provided this information when

discussing the lack of integration at the national level. The staff at the facility level responsible for providing ANC and EPI services (or maternal delivery services in Malawi) was also responsible for the distribution of LLINs.

> *"At health facility level it is more integrated, because at the national level we have specific officers for each program, but at facility level there is no specific person, so everything is integrated." (National EPI Programme, Malawi)*

> *"Every program has its own specificities, but at the operational level they are all integrated. For example, at the health centre level, when a pregnant woman comes she receives the ANC, but she is also given a mosquito net to prevent malaria, she goes through HIV screening, etc. So you can see that it is integrated." (National Malaria Programme, Mali)*

LLINs were described as an incentive to attend EPI services in all four countries, and especially in Mali and Rwanda, where the final vaccination visit was used for LLIN distribution. Health workers in Mali also identified the free LLIN as a positive incentive to attend ANC services (which are not free in Mali), and noted that in times of LLIN stock-out people were disinclined to attend routine services.

> *"After sometime, we started to face stock out [of nets] and financial problems and the people stopped visiting the health centres. I think if the government could ensure the continuity of the supply of nets and other health commodities there would not be a problem. That is to me the only reason that negatively impacts the implementation of these policies." (District Health Office, Mali)*

A notable challenge was observed in Malawi where children were supposed to receive LLINs at birth or upon first contact after birth. In practice, LLINs for infants were distributed in the maternity ward at the time of birth. There was no clear system in place, however, through which infants who were not delivered in the maternity ward could be identified and provided an LLIN. When children were delivered outside the health facilities, the first point of contact with health services was often EPI. The EPI programme in Malawi was implemented primarily by health surveillance assistants (HSAs) at the facility level. These HSAs were not involved in the LLIN programme and worked semi-autonomously from the rest of the health center staff. These HSAs did not track or follow LLIN distribution and did

not actively refer families to the delivery ward to receive an LLIN unless prompted by the mother herself.

> *"You know most of the immunization is being done by HSAs and these people undergo a 12 weeks training including training about EPI services." (National EPI Programme, Malawi)*

All facilities across the four countries noted a lack of human resources available to provide services and reported days when there were more clients and workload than was manageable for the staff. This was described more often as an issue for ANC services than for EPI. Strategies to manage included: 1) Turning women away on that day and requesting that they return on another day (Malawi); 2) Completing only part of the intended services, and planning to provide the remainder of services at the next visit – the services withheld tended to be complete history taking, health education, and non-commodity interventions (Kenya); 3) Providing all the services and activities to women but delaying data collection/record keeping until a future point in time (Rwanda). In all countries, health staff reported that data collection was most likely to suffer when the work load was heavy.

> *"As the In-Charge, what I have noticed is that when health workers have more work to do than what the time can allow, they are likely to omit some things and what is likely to suffer is now the data. So, I'd rather give the mother the net and whenever she goes I think, later I'll write. Later on, then maybe you can tend to forget." (Health facility, Kenya)*

6.5.3. Non-compliance with distribution policy

Facilities in all four countries reported instances in which LLINs were either provided to or withheld from women and/or children in ways that were not in line with the national policy for continuous LLIN distribution. Examples of extra LLIN distributions included: families with multiple small children who repeatedly appeared at the health facility with malaria cases; women who began ANC visits in other areas or other countries and had not received an LLIN; and very poor women who received LLINs during ANC but whose nets were lost or damaged. The examples reported in the interviews of extra LLINs distributed outside of policy always involved reproductive-aged women and children, teenagers, the elderly, or migrant populations. Men were never identified as the recipients of extra LLINs.

"You get a mother, has three kids, one of them malaria is positive and they don't have a mosquito net. Even telling her to get that 50 shillings to buy a net she cannot. So you just have mercy and you give." (Health Facility, Kenya)

Withholding LLINs, despite policies to provide them, was also reported in facilities. In one facility in Kenya, fear of stock shortages led health workers to provide only the ANC-based LLIN to pregnant women, and withhold the EPI-based LLIN despite knowing the policy guidelines. In this case, the health worker interviewed did not believe there was a benefit in providing an LLIN to the infant, and was concerned about stock-outs if the policy was followed. Staff at one facility in Malawi reported turning women away from ANC if they did not come with their husbands. Another facility in Malawi reported refusing ANC services to women who wished to opt-out of HIV testing, and noted that as a result fewer women came for ANC services for fear of HIV testing. And, in two facilities within Rwanda, continuous LLIN distribution was withheld from both primigravid pregnant women and children following a recent mass campaign.

"For the ANC, we give nets to women who are in their first pregnancy and who did not get any net during the mass distribution campaigns." (Health facility, Rwanda)

At the facility level, staff expressed concerns that other vulnerable groups were neglected by the policies, including the elderly, health center in-patients, and women staying in the delivery wards.

6.5.4. Supervision

Staff reported that supervision of health facility work was conducted most frequently by sub-national-level health officers for general service delivery, and by partner organizations for specific programmes. At the national and sub-national levels in all countries, effectively implementing supervision was seen as a challenge.

"The monitoring and supportive supervision - that's I think our biggest challenge. Making sure that the data is correct and that the nets actually reach the target beneficiary." (Partner Organization, Kenya)

The different health programmes in each country often reported combined supervision activities and addressed multiple programmes and aspects of service delivery in one visit. Notably, reproductive health and malaria reported combined supervision activities more

frequently, reinforcing the integration of these programmes, while EPI reported rarely integrating supervision, except in the case of Malaria Vaccine trials (with malaria unit) and Human Papilloma Virus (HPV) vaccine (with youth services) in Kenya and Malawi respectively. As a result, LLINs were not emphasized during EPI supervisory activities.

> *"During the vaccination exercises, we record each antigen that we use and the quantity. This data is compiled in a report at the end of the month and sent to the region for analysis." (District Health Office, Mali)*

Staff at the sub-national level expressed concern that combined supervision would not allow enough time for each service. Staff also reported that new policies and guidelines often took time to reach all the staff involved in a given program, and that information did not get shared between programmes.

> *"If there is new information it takes a long time to reach us. Sharing of information is not done well." (District Health Office, Malawi)*

6.5.5. Data collection and use

Data Collection

A review of data collection tools and reporting forms in the facilities visited in the four countries revealed that data on LLIN distribution through ANC were more consistently collected and reported compared to data on distribution through EPI. This was especially true for ANC- and EPI-specific data collection tools, and reporting. All four countries collected both ANC- and EPI-based LLIN distribution data in the maternal and child health booklets that were kept by mothers to track pregnancy and child health. In all countries this booklet was described as the means by which health workers tracked LLIN distribution to families.

> *"In the health booklet we have our own rubber stamp that we stamp in there so that we know this child was given or the mother was given [a net]" (Health facility, Kenya)*

All countries had an LLIN-specific register and a specific LLIN monthly report, often produced by partner organizations, which captured individual data on LLIN continuous distribution through both programmes. These registers were most often used for stock tracking, and reporting to partner organizations.

In all four countries the ANC register included a column to indicate that an LLIN had been provided to the woman during her pregnancy, and this column was generally used in all countries. In Rwanda and Kenya there were columns to capture the LLIN distributed to infants in the EPI and Child Welfare Registers, respectively. In Rwanda, the column was not used in any of the facilities visited, and staff reported using other methods to track LLINs instead. In Kenya, there was a space for the EPI-based LLIN in the Child Welfare Register, but the space was not filled-in in any of the facilities visited. Facility staff explained that the Child Welfare Register was kept and managed by staff as a client intake register, capturing name, village, weight, etc., rather than a service delivery register. As a result, the health workers using this register were unaware of LLIN distribution status. Alternatively, in two health facilities in Kenya the EPI staff re-purposed the 'yellow fever vaccine' column within the EPI register to record LLIN-distribution, indicating that when captured efficiently the data collected were useful for health workers. In Mali and Malawi, the routine EPI and child health registers did not provide a specific space to capture information about LLIN distribution. Likewise, the maternity register in Malawi did not contain data on the LLIN distributed to infants during that point of contact. National malaria staff expressed interest in including LLIN data in new EPI registers being designed for new vaccine introduction. However, national EPI staff in each country reported that new registers had already been designed and printed without a space for such data.

Data Use

There were also differences in the attention given to LLINs in the data reports sent to higher levels. The Maternal Health programme in all four countries tracked LLIN data as an indicator for ANC performance at the facility level, by sending tallies of LLINs distributed to pregnant women as part of facility ANC reports. By comparison, EPI-based LLIN distribution was not captured within EPI-reports as an EPI performance indicator in any country.

> *"For the EPI program, I collect [data on] the antigens. I have a register where I write the type, quantity and recipient of each antigen ... For the ANC program, we record also all the commodities that are used for the service delivery and the quantities. We also record the number of nets that we distribute ... All the data is recorded in registers." (District Health Office, Mali)*

At national level, ANC and EPI programmes both reported using facility data on routine services to track programme progress. By contrast, national malaria programme staff, when asked how progress was measured, reported using primarily survey data.

> *"Annually we are conducting the survey just to assess how much we have achieved in terms of coverage" (National Malaria Programme, Malawi)*

6.6. Discussion

From our analysis, ANC-based continuous LLIN distribution is more established and better integrated than EPI-based distribution. Analysis of LLINs distributed in Africa via ANC and EPI found that on average LLINs were available for 55% of women attending ANC while they were only available for 34% of children attending EPI.[216] Looking more closely at ANC and EPI programmes, this difference may not be unexpected. ANC could be defined as a collection of diverse interventions intended to improve pregnancy and birth outcomes, while EPI is a more narrowly defined programme intended to deliver vaccinations.[37,195,218] This difference highlights the ease in which LLINs can be incorporated into ANC, and the challenges that are presented when integrating with EPI. From a policy perspective, the addition of another intervention is accepted within ANC if it provides a benefit for pregnancy-related health outcomes. Likewise, prevention of malaria during pregnancy is a central focus of ANC in sub-Saharan Africa and within the global malaria control community, and is also the topic of much research.[75,80,101,219] It is, therefore, understandable that ANC programmes would actively monitor and track LLIN distribution.

By comparison, the addition of a non-vaccine intervention into EPI may be more difficult. EPI programme staff, both nationally and globally, promote integrated delivery of child health interventions,[31] but the ownership, implementation and monitoring of interventions still seems to be segregated. This was illustrated in the separate supervisory activities as well as the lack of data collection and reporting on LLINs by EPI programmes, identified in this qualitative evaluation.

Few studies have looked at EPI and LLIN integrated service delivery.[48,60] These papers did not investigate the operational challenges to integration, but did find that the integration of EPI and LLIN distribution has the potential to increase net use in children and decrease malaria in this vulnerable group,[48] and that it is well accepted by health workers and families.[60] There is a much larger body of work studying integrated EPI with other non-

vaccine programmes and has found similar challenges to those discussed here. While the potential benefits include cost-effective delivery and improved coverage, common barriers identified have been monitoring and evaluation of integrated activities, vertical programming, and staff time demands.[46,63,220–222] Despite these challenges, the benefits are seen to outweigh the challenges, and integration with EPI has become more common in recent years.[47]

Data concerning LLIN distribution to infants was not properly collected or reported within EPI and child health registers in the countries visited. One reason for this may be that routine facility data are not systematically used by national malaria programmes to track malaria LLIN programme progress. These routine data could be better utilized by malaria control programmes. Routine data, collected through both LLIN-specific registers, as well as ANC and EPI programme registers, would provide malaria programmes with multiple sources of data to compare, beyond survey data, leading to a better understanding of continuous distribution performance.

In terms of the implementation, while generally health facility staff understood and implemented policies appropriately, there were inconsistencies and instances of non-compliance. Similarly, in Ghana, Webster *et al* also found that health workers made independent decisions about when to provide new nets and who needed new nets that diverged from the official policy.[104] These findings highlight the need for more consistent supervision and explanation of policies. Previous research in both Ghana and Malawi similarly reported that LLINs may serve as an incentive to attend routine ANC and EPI services.[48,104]

Due to the limited time available, only 7-11 interviews were conducted with 13-23 participants in each country, and only 'average performing' facilities (in terms of malaria/LLIN delivery and general services according to the Ministry) were included, leaving out the strongest and weakest. Thus, it was also not possible to create a representative sample of facilities, and our findings may therefore not capture the total breadth of experiences in each country. Nevertheless, common experiences were recorded and reiterated across countries and interviews, suggesting a theoretical saturation was met for the interviewees on the main topics.

In larger group interviews, especially in cases where supervisors and general staff participated at the same time, staff may have felt less free to speak honestly about work challenges. While interview questions targeted specific programmes and staff, the responses were not always evenly distributed, with supervisors speaking more than other staff in some cases. Divergent experiences and opinions, or criticism of policies may have been voiced less frequently in these cases. In one case, despite the intention in the protocol to prevent this, a senior programme staff member was present at some facility interviews which may have interfered with staff feeling comfortable enough to speak freely about their experiences. The national EPI perspective in Mali was also not included because the national staff was unavailable at the time of the evaluation; EPI staff at the sub-national and facility level was included.

Despite these limitations, the interviews revealed important challenges in the continuous distribution of LLINs. Through the experience of stake holders in these four countries, and the review of documents at the national and facility level, it was possible to identify key differences between ANC and EPI based LLIN distribution. These findings also highlight areas for improvement both within ANC and EPI based distribution, which could advance the consistency and efficiency of LLIN distribution in these countries.

6.7. Conclusions

The continuous distribution of LLINs, through the routine channels of ANC and EPI, provides an important service during pregnancy and infancy, and is an essential supplement to campaigns in the maintenance of universal LLIN coverage. The continuous distribution system in the four countries visited have been designed and implemented well, however common challenges exist related to: a) the lack of integrated management, and b) inconsistent data collection and data use, especially for LLIN distribution through EPI. More consistent integration at the national level, especially between malaria and EPI, may provide more oversight and support to improve programme performance. While the EPI programme may have had little responsibility for non-vaccine services in the past, the risk of LLIN stock-outs negatively impacting programme uptake may be a strong argument for greater EPI involvement. Likewise, using LLINs as an incentive to promote EPI attendance may encourage EPI programme staff to become more involved.

Strengthening routine data collection and reporting systems for LLIN distribution, especially through ANC and EPI service registers, can support improved programme monitoring.

These data, when collected effectively, offer a way to assess the total LLINs distributed to women and children served through ANC and EPI, and may help to identify gaps in service delivery and strengthen integration. At the global level, support and attention to improved integration for the continuous distribution of LLINs, including the use of process indicators from service delivery data, can improve these distribution channels, and their effectiveness at reaching women and children.

6.8. Ethical Approval

The protocol was reviewed and approved by the London School of Hygiene and Tropical Medicine (LSHTM) and the Johns Hopkins Bloomberg School of Public Health ethics review boards. In each country the national malaria programme provided approval, and supported the data collection as part of a routine programme evaluation.

6.9. Authors' contributions

Study conceived and designed by: KTN; Tool design contributions by: JW, JL; Interviews conducted by: KTN; Data analysis by: KTN; Written by: KTN; Critical review of analysis and interpretations by: JL, JW; Editorial inputs by: DK, CK, WE, DA, JL, JW.

6.10. Acknowledgements

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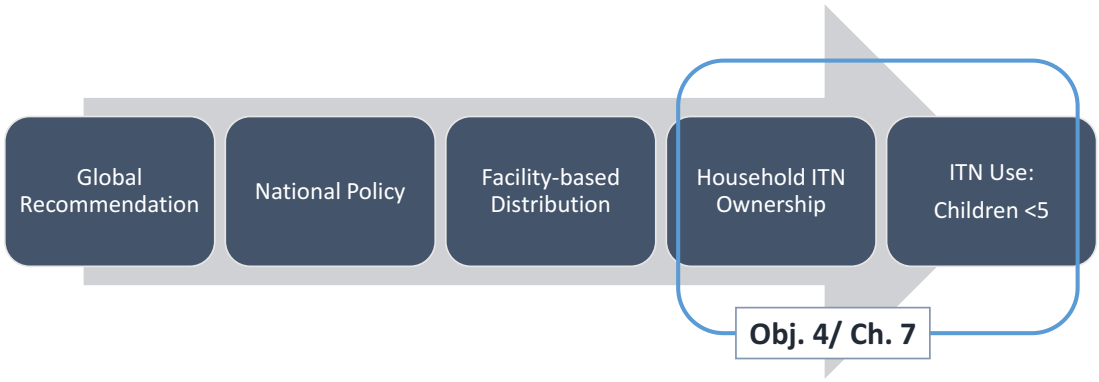
CHAPTER 7: CAN ITN DISTRIBUTION POLICIES INCREASE CHILDREN'S ITN USE? A DHS ANALYSIS

Chapter 7 addresses the forth objective of this thesis, to analyse the impact of facility-based continuous distribution policies in Africa on household net ownership and net use in children under-five years of age.

Chapter 7 looks specifically at the household ITN ownership and ITN use for children under 5, in countries with and without routine facility-based distribution policies. This analysis was conducted using DHS data, made publicly available by USAID for research. The DHS datasets do not include information on national policies or ITN distribution methods, so this analysis relied on country categorization identified in chapter 4. This chapter attempts to assess what impact routine facility-based ITN distribution might have on ITN ownership and use (Figure 20).

Figure 20: Process elements included in Chapter 7



This chapter has not been published, but does include the LSHTM Cover Sheet for research papers included in a research thesis.

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SECTION A – Student Details

Student	Katherine Theiss-Nyland
Principal Supervisor	Paul Fine
Thesis Title	Integrating insecticide treated nets with routine antenatal care and immunization programmes: policy, practice, and coverage

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

Where was the work published?			
When was the work published?			
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*	Yes	Was the work subject to academic peer review?	Yes

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	The intended journal has not been decided, but both Malaria Journal and Lancet Global Health have been discussed as potential journals for submission. An alternative journal may be identified once the paper is ready for submission.
Please list the paper's authors in the intended authorship order:	Katherine Theiss-Nyland will be the first author. The final list of co-authors has not been decided, but may include Lenka Benova, Sujit Rathod, Jo Lines, and/or Paul Fine, depending on their interest and contributions when this paper is finalized for submission.
Stage of publication	**Not yet submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I, Katherine Theiss-Nyland, will be the first author on this paper. I was responsible for the study design and analysis. I also wrote the complete article, as it is presented here. The potential co-authors, listed above, supported this work as advisors, assisting with statistics, and providing feedback on the direction of the research and the clarity of the writing.

Student Signature: [redacted] **Date:** __20/03/2017___

Supervisor Signature: [redacted] **Date:** ___20/03/2017____

Can ITN distribution policies increase children's ITN use? A DHS analysis

This paper has not yet been published

7.1. Abstract

Background

Insecticide treated nets (ITN) have largely been distributed via mass distribution campaigns. Since 2011, however, the WHO has recommended ITN distribution via the routine channels of ANC and EPI services. Countries have begun to implement these routine facility-based distribution strategies, but inconsistently, and there is little research on outcomes of these new programmes. This paper investigates the impact of ITN distribution policy on children's net use, comparing countries with and without the policy in place.

Methods

DHS surveys from 25 countries in Africa were used to analyse household ITN ownership, and ITN use among children under five years of age. All countries with a DHS analysis since 2010, and ITN ownership data were included. Countries were categorised in terms of the ITN facility-based distribution policies in place, based on nationally reported policies and distribution data provided to WHO. The analysis was conducted for individual countries and then pooled with all countries in each category weighted equally to present the average country experience, by ITN distribution policy.

Results

Household ITN ownership, children's ITN use, and children's ITN use in households with at least one ITN increase with each additional routine facility-based distribution policy. An average of 54.0% of children slept under an ITN in countries with ITN distribution via ANC and EPI, compared to 34.3% and 24.7% in countries with ITN distribution via ANC only, or no facility-based distribution, respectively. Linear regression found a 13% increase in net use among children under 5, on average, with each additional ITN distribution policy.

Conclusion

ITN distribution via ANC and EPI can not only assist countries in maintaining ITN ownership and use in children under five, but may be extremely effective at increasing ITN ownership

and use. There is also an additional benefit to ANC and EPI-based ITN distribution combined, compared to ANC distribution alone, for children under five.

7.2. Background

Long lasting Insecticidal Nets (LLINs) are one of the most effective tools for preventing malaria. As a result, LLINs have become the primary malaria prevention strategy recommended and championed by the World Health Organization (WHO) global malaria control program.[194]

Early mosquito net distribution efforts focused on pregnant women and children, as the most vulnerable to severe malaria morbidity and mortality. More recent strategies have focused on "universal coverage", with the intention of providing ITNs for all people in areas with a high malaria burden. WHO recommends household ownership of nets equal to one net for every 2 household members.[10] The Roll Back Malaria (RBM) strategic plan's 2015 target stated that at least 80% of all members of populations at risk for malaria should be sleeping under an ITN on any given night.[66,120]

Since the mid-2000s, mass campaigns of free insecticide treated nets (ITNs) have been the most common distribution strategy,[23,25,26] accounting for 86% of the nets distributed in Africa.[216] The provision of free nets has dramatically increased ownership across Africa in the last decade.

Recognizing that campaigns are not enough to ensure ITN coverage over time, new continuous distribution strategies have been developed to improve and maintain coverage in concert with campaigns. These strategies often focus on providing ITNs to the most vulnerable groups: pregnant women, infants and children. One such strategy, now recommended by the WHO is the routine facility-based distribution of ITNs via both antenatal care (ANC) and childhood vaccination (EPI) programmes.[68] These recommendations specifically state that an ITN should be distributed to every woman at her first antenatal care visit in conjunction with other health interventions to assess and support the needs of a pregnant woman. By comparison, the recommendation for ITN distribution through EPI states that every child attending vaccination services receives an ITN, but it does not recommend at which vaccination visit within the first year of life the distribution should take place, leaving it to countries to make a decision for themselves. In

most countries, there are at least five vaccination visits between birth and one year of age with could be used as a platform for ITN distribution.

Despite these recommendations, many countries have yet to implement routine facility-based ITN distribution, or have only implemented distribution via ANC. Distributing ITNs via ANC has been a significant topic of research, which finds that ANC distribution, in combination with campaigns improves ITN ownership.[98,109,110] ANC has been the focus of routine facility-based distribution with the assumption that new born babies will share a net with their mother, especially while they are breast feeding. ITNs distributed via ANC will therefore cover both the pregnant mother and the new-born child.

Models developed to assess the benefit of different ITN distribution channels may not account for the increasing household size that results from a new birth.[110] While ITNs distributed via ANC may successfully replace campaign nets that have worn out between campaigns, new-born babies will increase the size of a household, thus increasing the total number of ITNs needed to cover all the household members. These growing households might benefit for additional ITN distribution through EPI. Research has yet to look at the benefits of ITN distribution through ANC and EPI together, as compared to ANC alone; a distribution strategy which could address some of these issues.

Analyses clearly show that ITN use is a function of ITN ownership: the more ITNs in a household, the more people sleep under ITNs.[134] By age, there are also clear patterns across countries, with the highest use being by new-borns and pregnant women, and the lowest use by young adults 11-19 years of age.[1] The decline in net use from birth begins immediately. This analysis focuses on children under five, as one of the groups targeted by both ANC and EPI-based ITN distribution. While pregnant women will clearly benefit from ANC based distribution, this analysis will investigate the benefit that both ANC and EPI-based distribution of ITNs have on children under 5, as the more distant target of these programmes.

Specifically, this research looks at the net use of children under-five comparing countries with no routine distribution through ANC or EPI, to countries with only ANC distribution, and countries with both ANC and EPI based distribution of ITNs.

7.3. Methods

Data

This analysis was conducted using the most recent Demographic Health Surveys (DHS) in sub-Saharan Africa from 2010 to present. Each DHS survey has a nationally representative sample of between 5,000 and 30,000 households. The surveys consist of three questionnaires (Household, women's and men's) and include interviews with all women in each household between the ages of 15 and 49 years, and a subset of men. The data are compiled into recoded datasets for use. The DHS uses a multilevel cluster-sampling survey design. Countries were included in the analysis if they collected information on type of mosquito nets present in the household and ITN use by household members.

Children born to interviewed women within the 5 years preceding the survey, and alive at the time of the survey, were included in the analysis. The children's recode and the household recode were used to include all variables of interest.

Variable/Definitions

ITN use: The main variable of interest for this analysis was the "use" of (i.e. sleeping under) a treated (either ITN or LLIN) bednet the night before the survey. Untreated nets were excluded.

Household access: Access is an individual variable derived from the ITN availability within the individual's household. Access is generally presented as the proportion of a population with access to an ITN within their household. Access is calculated at the household level as one ITN per two people per household, and then applied to all individuals within that household. Household access is the proportion of the household with access to an ITN. This variable was calculated using "de facto" household members in the household dataset: i.e. household members recorded as present the night preceding the survey. A household with at least one net per two household members, enough ITNs for all, is defined as having *universal access*.

Facility-based distribution policy: Countries were categorized as having no policy if they had not reported such a policy to WHO or had not reported any years of net distribution through these channels.[1,216] Countries were categorized as having ANC and/or EPI based distribution if they had reported such a policy to WHO and/or had more than one reported

year of ITN distribution through each of these channels since 2010.[1,216] All countries with ANC and/or EPI-based distribution policies have had such a policy since before 2010.

Analysis

Household ITN ownership, and ITN use for children under-five years of age, was explored and stratified by the facility-based distribution policies present in countries. Countries were also compared in terms of the African Leaders Malaria Alliance (ALMA2030) score for ITN/IRS operations. ALMA2030 is coalition of African leaders implementing a monitoring and accountability system in an effort to decrease and eliminate malaria by 2030. Each country receives a score, out of 100, identifying how well the country has performed in a given category. In this analysis, the ALMA scores for ITN/IRS operations for each country were compared to look for significant differences in the countries implementing routine facility-based distribution, as compared to the countries that were not.

Each analysis was first conducted for each country individually to look for any possible variation. For individual country analyses, internal weights from the DHS were maintained to present nationally representative statistics. For multi-country summaries and pooled analyses, all countries were weighted equally to present an average country statistic.

Countries were weighted equally, rather than weighted by population to present the average experience individuals might have under different policies. Each country has implemented a single policy plan, and as a result, the individual experience with ITN distribution is largely dependent upon the policy in place. At the same time, there is likely significant variation between countries implementing the same policy. Each country experience represents a true outcome of policy implementation. The intention of this analysis is to illustrate the possible outcomes a country might experience when choosing to implement a given policy over another. Simple averages, with countries weighted equally, were used to allow each country experience to equally influence the estimated average. If the countries were weighted by population, the experience in Nigeria, for example, would dominate the expected outcome for any country implementing the same type of policy that Nigeria has. However, all the people in Nigeria are only experiencing one example of that policy. By giving each country an equal weight, the analysis provides an estimate of the average country experience for each policy decision.

Analyses were presented either for all households, or for households with at least one ITN. All analyses were completed using Stata version 13 and 14. All the analyses accounted for the survey design, using either sampling weights or the svy commands in Stata.

7.4. Results

Across all countries, the odds of ITN use generally decreased with age up to five (Table 17). A pooled analysis of all countries showed that children zero and one year old had roughly the same odds of ITN use, which decreased for two, three, and four year olds respectively (Table 17). Gender in under-five year olds did not have any effect on ITN use, with the exception of Mali, Guinea and Rwanda. In Mali female children were less likely than their male counterparts to use ITNs: OR=0.84 (95% CI: 0.74-0.95), while in Guinea and Rwanda female children were slightly more likely to use ITNS: OR=1.24 (95% CI: 1.07-1.43) and OR= 1.11 (95% CI: 1.01-1.23) respectively (Table 17). With multiple comparisons, there is an expectation that at least one will produce a significant difference by chance alone. A heterogeneity chi-squared for gender and ITN use across all countries was χ^2=13.62, p=0.96, supporting that conclusion and suggesting that there is no true difference between countries.

Table 17: Odds ratio for sleeping under a treated net for children aged 1-5 years compared to infants, and by gender, in houses with at least one ITN, unadjusted

Country *	OR of net use given age (95% CI)					OR by gender (95% CI)	
	<1 year	1 year old	2 years old	3 years old	4 years old	Male	Female
Benin	Ref	1.06 (.88-1.27)	1.00 (.83-1.20)	0.79 (0.66-0.93)	0.71 (0.59-0.84)	Ref	1.05 (0.94-1.18)
Burkina Faso	Ref	0.94 (0.79-1.11)	0.77 (0.65-0.99)	0.61 (0.52-0.70)	0.47 (0.40-0.55)	Ref	1.06 (0.96-1.17)
Burundi	Ref	1.30 (1.00-1.69)	0.67 (0.53-0.84)	0.58 (0.47-0.72)	0.46 (0.36-0.59)	Ref	1.00 (0.84-1.16)
Cameroon	Ref	0.96 (0.72-1.27)	0.81 (0.63-1.04)	0.50 (0.39-0.65)	0.54 (0.41-0.71)	Ref	0.92 (0.77-1.11)
Congo	Ref	1.12 (0.75-1.68)	0.86 (0.66-1.13)	1.02 (0.74-1.42)	0.87 (0.57-1.33)	Ref	0.82 (0.64-1.04)
Cote d'Ivoire	Ref	1.14 (0.94-1.38)	0.94 (0.78-1.13)	0.78 (0.63-0.97)	0.74 (0.61-0.91)	Ref	0.98 (0.85-1.13)
DRC	Ref	0.99 (0.82-1.19)	0.73 (0.61-0.87)	0.56 (0.47-0.67)	0.51 (0.43-0.60)	Ref	0.91 (0.82-1.01)
Gabon	Ref	0.64 (0.42-0.98)	0.59 (0.39-0.90)	0.53 (0.35-0.79)	0.43 (0.28-0.66)	Ref	1.13 (0.86-1.49)

Ghana	Ref	0.76 (0.61-0.95)	0.75 (0.59-0.96)	0.70 (0.55-0.90)	0.58 (0.46-0.73)	Ref	0.86 (0.74-1.00)
Guinea	Ref	1.08 (0.86-1.37)	0.88 (0.71-1.10)	0.90 (0.70-1.14)	0.65 (0.53-0.80)	Ref	1.24 (1.07-1.43)
Kenya	Ref	0.93 (0.79-1.10)	0.76 (0.64-0.90)	0.56 (0.47-0.65)	0.57 (0.48-0.67)	Ref	0.86 (0.78-0.95)
Liberia	ref	0.65 (0.50-0.84)	0.55 (0.43-0.70)	0.50 (0.37-0.68)	0.43 (0.34-0.54)	Ref	1.05 (0.89-1.25)
Malawi	Ref	1.00 (0.87-1.15)	0.82 (0.72-0.94)	0.78 (0.67-0.90)	0.66 (0.57-0.77)	Ref	1.10 (1.00-1.21)
Mali	Ref	1.07 (0.87-1.30)	0.82 (0.67-1.00)	0.67 (0.56-0.80)	0.57 (0.48-0.69)	Ref	0.84 (0.74-0.95)
Mozambique	Ref	0.93 (0.77-1.14)	0.76 (0.63-0.93)	0.62 (0.52-0.73)	0.53 (0.44-0.65)	Ref	0.99 (0.88-1.12)
Namibia	Ref	0.76 (0.50-1.16)	0.74 (0.1-0.96)	0.63 (0.41-0.96)	0.60 (0.37-0.98)	Ref	0.83 (0.61-1.13)
Nigeria	Ref	0.93 (0.82-1.06)	0.90 (0.81-1.00)	0.75 (0.67-0.83)	0.65 (0.57-0.74)	Ref	1.06 (0.98-1.15)
Rwanda	Ref	1.13 (0.94-1.35)	0.89 (0.75-1.06)	0.65 (0.55-0.77)	0.58 (0.49-0.69)	Ref	1.11 (1.01-1.23)
Senegal	Ref	1.07 (0.92-1.25)	1.01 (0.87-1.16)	0.93 (0.82-1.06)	0.91 (0.78-1.07)	Ref	1.06 (0.96-1.18)
Sierra Leone	Ref	1.05 (0.86-1.31)	1.03 (0.83-1.29)	0.87 (0.71-0.83)	0.66 (0.53-0.83)	Ref	1.02 (0.90-1.16)
Tanzania	Ref	1.10 (0.88-1.36)	1.00 (0.81-1.23)	0.91 (0.75-1.11)	0.96 (0.80-1.15)	Ref	1.07 (0.93-1.23)
Togo	Ref	0.89 (0.73-1.09)	0.79 (0.64-0.97)	0.71 (0.59-0.87)	0.79 (0.64-0.99)	Ref	1.03 (0.91-1.16)
Uganda	Ref	1.13 (0.91-1.40)	0.78 (0.64-0.95)	0.74 (0.60-0.90)	0.73 (0.58-0.92)	Ref	1.02 (0.89-1.16)
Zambia	Ref	0.93 (0.79-1.10)	0.75 (0.65-0.87)	0.59 (0.50-0.70)	0.53 (0.45-0.63)	Ref	0.97 (0.87-1.08)
Zimbabwe	Ref	1.05 (0.74-1.50)	0.94 (0.68-1.30)	0.83 (0.57-1.19)	0.72 (0.51-1.01)	Ref	1.16 (0.95-1.41)
All countries pooled	Ref	0.99 (0.95-1.04)	0.86 (0.82-0.90)	0.76 (0.73-0.80)	0.68 (0.65-0.71)	Ref	1.00 (0.97-1.03)

*No regional patterns were seen. Countries presented alphabetically.

7.4.1. Routine Facility-based Distribution Policy

The proportion of total households owning at least one ITN was greater in countries where there was routine distribution of ITNs through both ANC and EPI (average= 64.45%), as compared to ANC alone (average= 55.10%) or neither (average= 39.28%), (Table 18). Further, in countries with both ANC and EPI based distribution of ITNs, an average of 28.12% of households achieved universal access: enough nets for all household members, calculated as one net per two individuals (Table 18). By comparison, only 21.93% and

17.03% of households reached universal access in countries with ANC-based distribution, and no facility-based distribution, respectively (Table 18).

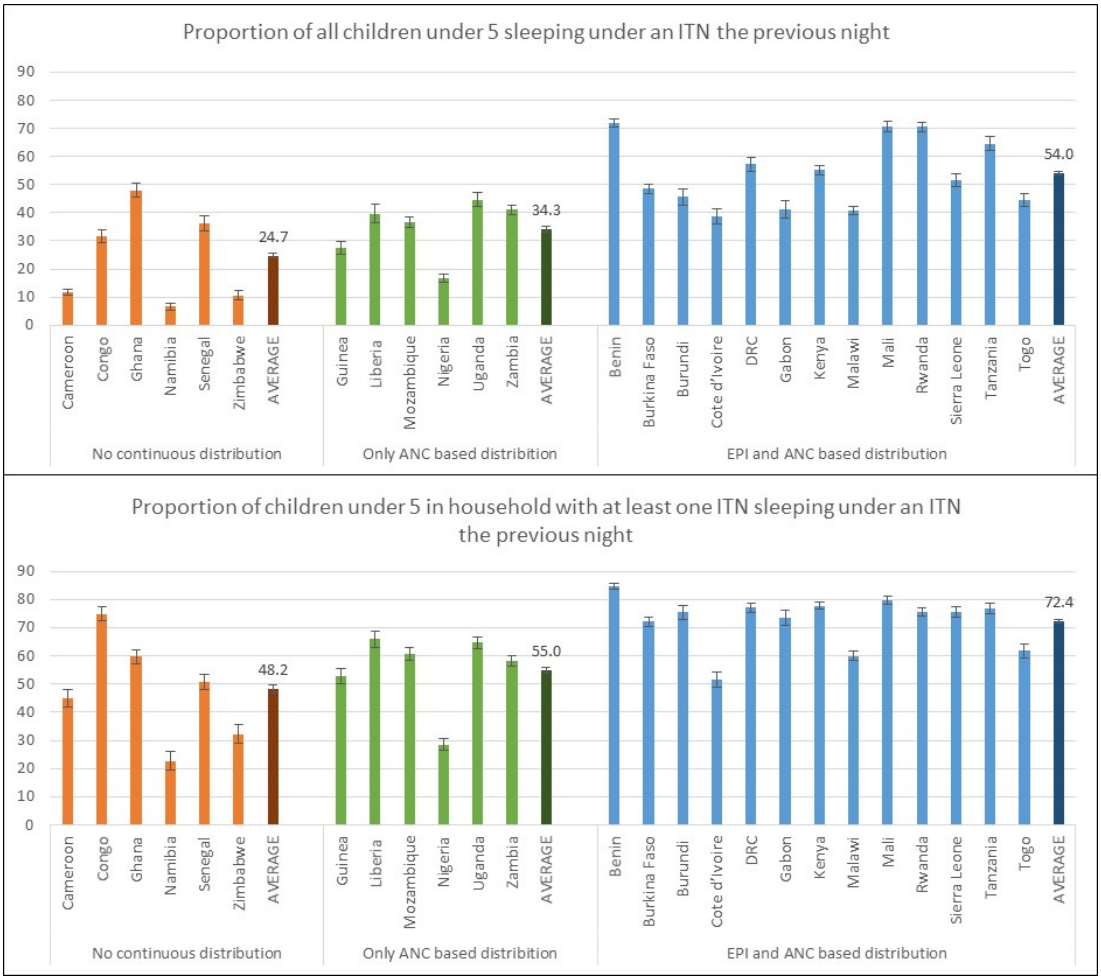
Table 18: Household ITN ownership by ITN distribution policy

Facility-based CD Policy	Country	DHS year	# of households surveyed	Living children under 5 years	% Households with at least 1 ITN (95% CI)	% Households with universal access* (95% CI)
ANC and EPI	Benin	2011	17422	12, 679	80% (78.7-80.8)	45% (43.4-45.8)
	Burkina Faso	2010	14424	13716	57% (55.3-58.6)	19% (17.4-19.6)
	Burundi	2010	8596	7231	52% (48.8-55.2)	24% (21.2-25.9)
	Cote d'Ivoire	2012	9686	7093	67% (64.6-69.8)	32% (29.9-33.5)
	DRC	2012	18171	17228	70% (67.6-72.2)	25% (23.8-26.9)
	Gabon	2012	9755	5747	36% (34.1-38.2)	15% (13.4-15.6)
	Kenya	2014	36430	20093	59% (57.7-60.2)	35% (33.4-35.6)
	Malawi	2010	24825	18360	57% (55.5-58.1)	20% (19.0-20.9)
	Mali	2012	10105	9582	84% (83.1-85.6)	42% (40.2-43.5)
	Rwanda	2010	12540	8484	82% (80.1-83.2)	40% (38.7-42.0)
	Sierra Leone	2013	12629	10618	65% (62.3-66.5)	15% (14.0-16.0)
	Tanzania	2010	10300	7526	64% (62.1-65.5)	23% (21.8-24.3)
	Togo	2013	9549	6535	65% (63.6-67.1)	33% (31.3-34.6)
Average					64.5%	28.1%
ANC only	Guinea	2012	7109	6424	47% (45.2-49.6)	10% (8.8-10.8)
	Liberia	2013	9333	7058	55% (51.6-57.6)	22% (20.4-23.9)
	Mozambique	2011	13919	10291	52% (49.5-53.3)	23% (21.1-24.1)
	Nigeria	2013	38522	28596	50% (47.7-51.4)	22% (21.0-23.3)
	Uganda	2011	9033	7355	60% (57.7-61.9)	28% (26.1-29.4)
	Zambia	2013	15920	12714	68% (66.3-69.1)	27% (26.2-28.5)
Average					55.1%	21.9%
No CD	Cameroon	2011	14214	10734	18% (17.4-19.2)	5% (4.1-5.0)
	Congo	2011	11632	8857	33% (31.2-35.0)	11% (10.0-12.2)
	Ghana	2014	11835	5595	68% (66.7-70.0)	45% (43.6-46.9)
	Namibia	2013	9849	4818	24% (23.0-25.9)	12% (11.0-13.1)
	Senegal	2010	7902	11633	63% (59.8-66.0)	17% (15.7-18.5)
	Zimbabwe	2010	10828	5203	29% (26.1-31.7)	12% (10.7-14.2)
Average					39.3%	17.0%

* Proportion of HH with enough nets for all HH members, defined as one net per two people per household

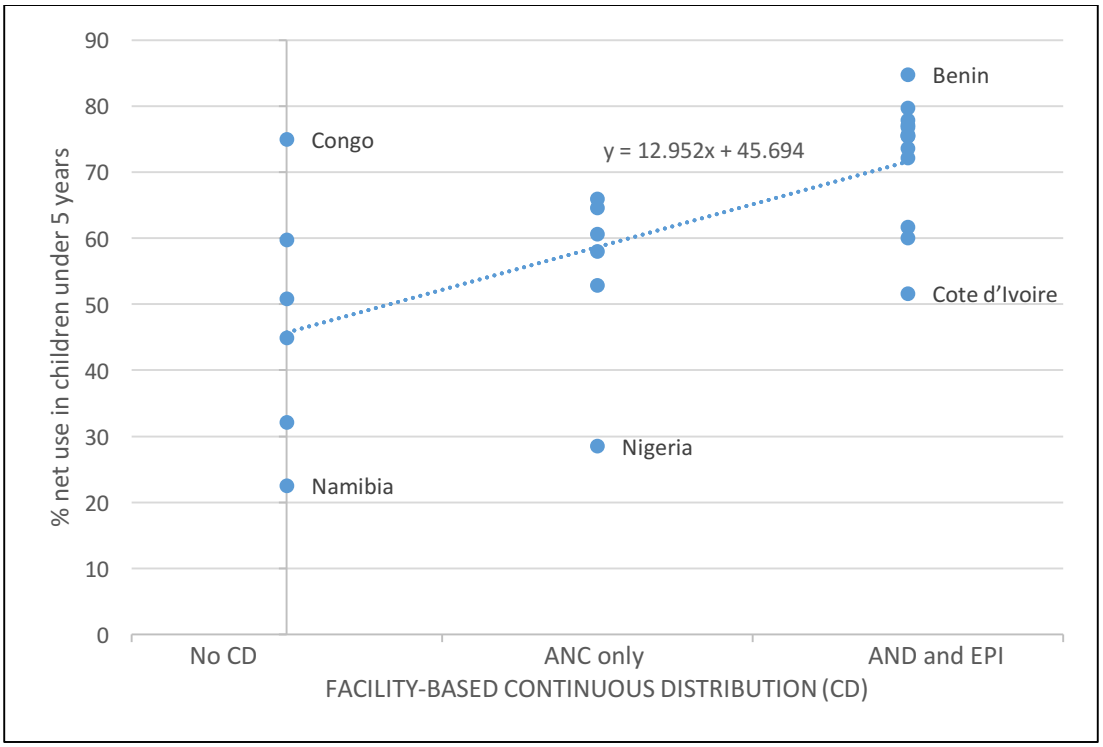
Beyond household ownership, in countries with both ANC and EPI-based ITN distribution, children under-five were more likely to be sleeping under an ITN than children in countries with only ANC based distribution or with neither (Figure 21). The average proportion of children sleeping under an ITN in countries with both distribution channels was 54.0% (95% CI: 53.3-54.6), compared to 34.3% (95% CI: 33.3-35.2) in countries with only ANC based distribution, and 24.7% (95% CI: 23.9-25.6) in countries with neither distribution channel (Figure 21). Excluding households with no ITNs, on average 72.4% (71.8-73.0) of children slept under ITNs in countries with both ANC and EPI based distribution, compared to averages of 55.0% (53.9-56.0) and 48.2% (95% CI: 46.8-49.5) in countries with ANC-only and no facility-based distribution, respectively (Figure 21). A best-fit line for children's ITN use in households with at least one net predicts a 13.0% (95% CI: 6.8-19.1) increase in net use with the addition of each facility-based distribution policy (Figure 22).

Figure 21: ITN use by children under 5 years, by distribution policy



*Simple average used with all countries weighted equally to create an "average country" not "average individual"

Figure 22: Best fit linear regression of ITN use in children under 5, stratified by facility-based distribution policies



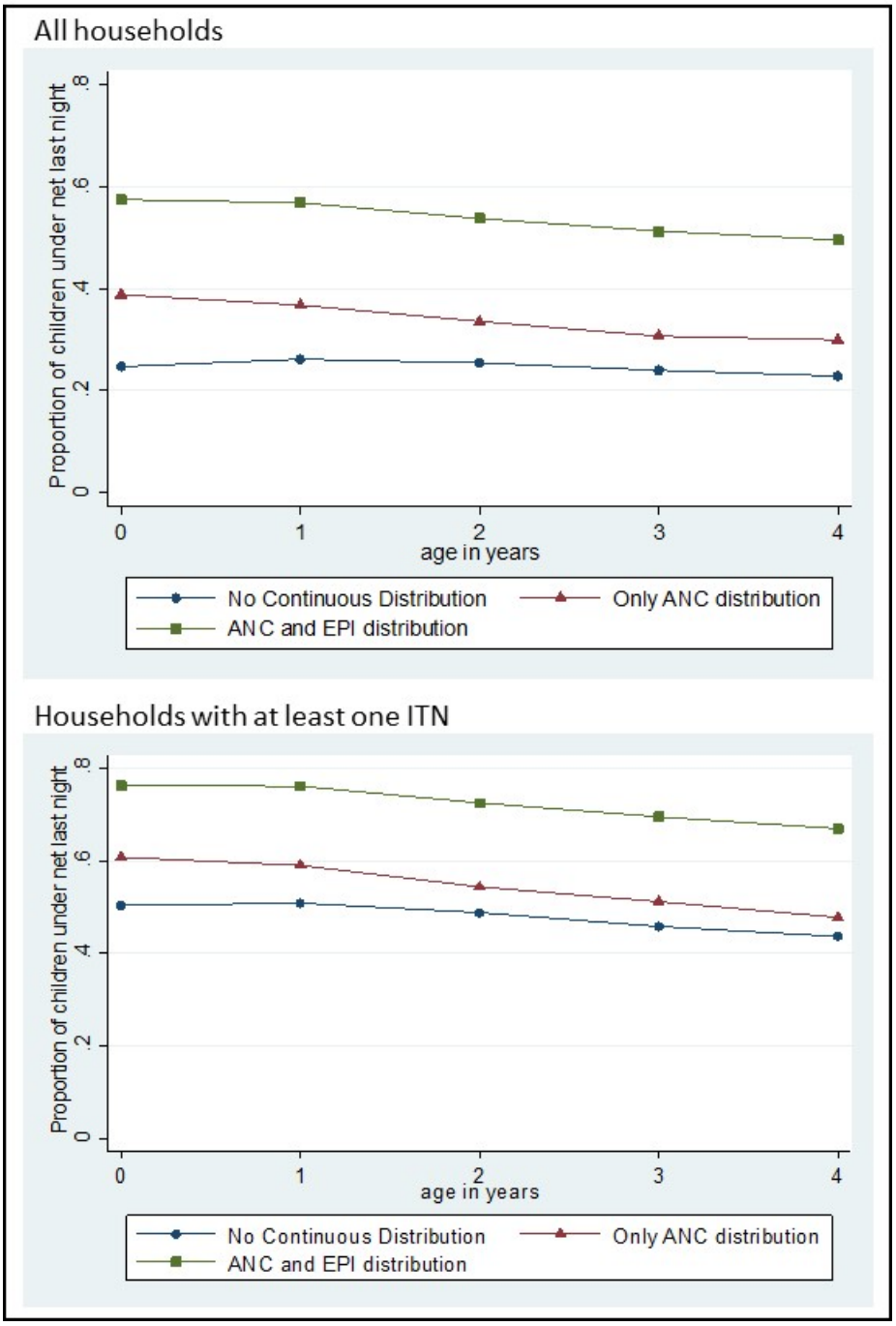
*Each dot represents one country proportion of ITN use in children under five, in households with at least one ITN. The best fit line produces an equation of y=12.95x + 45.69 where the increase in net use with each additional policy equals 12.95% (6.81-19.09) and 45.69 (36.34-55.05) represents the estimated proportion of children using an ITN in the category of no continuous distribution policy. Outlier countries have been labelled for convenience.

Using logistic regression, and controlling for maternal education and household size in all countries, the odds of a child sleeping under an ITN increases by OR=1.92 (95% CI: 1.86-1.97) for each additional distribution policy added. If the regression is limited to only households with at least one ITN, children are still OR=1.68 (95% CI: 1.63-1.73) times as likely to use an ITN with each additional policy, as compared to the children with one less policy.

When net use in children was pooled across countries, (with countries weighted equally to present the average country experience for each policy), the relationship between national policy and children's net use is seen. Children living in countries with both an ANC and EPI-based distribution policy were significantly more likely to be sleeping under an ITN, compared to children in countries with either ANC distribution only or no facility-based distribution policy, on average, for all age groups under-five (Figure 23). The same relationship was seen when looking only at households with at least one ITN (Figure 23).

Across all age groups, ITN use is significantly higher for children in countries with both ANC and EPI based distribution (Figure 23).

Figure 23: Net use by age, stratified by continuous distribution programme, in all households, and in households with at least one ITN



Countries weighted equally, not by population, to crease estimations for "average country experience" based on the policy options

Looking closely at ITN use by age, in the youngest children there appears to be a stepwise improvement in ITN use with the addition of each distribution policy. In older children, by

comparison, the addition of the EPI-based distribution policy seems to have a greater effect than the addition of the ANC-based distribution policy (Table 19). Infants benefit most from the addition of ITN distributed via ANC, while 4 year olds benefit most from ITNs distributed via both ANC and EPI, compared to only ANC (Table 19).

Table 19: Odds Ratio (OR) of ITN use by age, in all countries pooled, with ANC-based distribution only as a reference category, for all households and households with at least one ITN, controlling for maternal education and household size

	All households			Households with at least 1 ITN		
Age	No CD	ANC only	ANC and EPI	No CD	ANC only	ANC and EPI
<1 year	0.52 (0.48-0.57)	ref	2.12 (1.98-2.27)	0.68 (0.61-0.76)	ref	2.06 (1.90-2.23)
4 years	0.71 (0.64-0.78)	ref	2.28 (2.12-2.45)	0.88 (0.78-0.99)	ref	2.21 (2.04-2.39)

There was no clear trend between countries with no facility-based distribution policies, compared to those with ANC only, or ANC and EPI based distribution, in terms of the scores received for "operational ITN/IRS coverage" by the African Leaders Malaria Alliance (ALMA) in 2013 or 2016 (Table 20).[223] In 2013, the mean and range scores for countries was: no facility-based distribution: mean=85.5, range= 74-98; ANC only: mean=63, range=27-100; ANC and EPI: mean=71.2, range=14-100 (Table 20). In 2016: no facility-based distribution: mean=80.8, range=8-100; ANC only: mean=89.3, range=51-100; and ANC and EPI: mean=88.9, range=5-100 (Table 20).[223]

Table 20: African Leaders Malaria Alliance national scorecard for "Operational ITN/IRS coverage", 2013 and 2016

ITN distribution policy	Country	DHS year	ALMA score 2013	ALMA score 2016
ANC and EPI	Benin	2011	93	100
	Burkina Faso	2010	38	100
	Burundi	2010	82	100
	Cote d'Ivoire	2012	52	NA
	DRC	2012	62	100
	Gabon	2012	14	5
	Kenya	2014	100	95
	Malawi	2010	99	100
	Mali	2012	52	100
	Rwanda	2010	100	100
	Sierra Leone	2013	100	100

	Tanzania	2010	58	67
	Togo	2013	76	100
	Average		88.92	71.23
ANC only	Guinea	2012	62	51
	Liberia	2013	100	100
	Nigeria	2013	27	92
	Mozambique	2011	66	93
	Uganda	2011	46	100
	Zambia	2013	77	100
	Average		89.33	63.00
No facility-based distribution	Ghana	2014	91	100
	Cameroon	2011	74	100
	Congo	2011	79	8
	Namibia	2013	98	NA
	Senegal	2010	81	100
	Zimbabwe	2010	90	96
	Average		80.80	85.50

NA= Countries with missing data for 2016
The colouring of the scores is set by ALMA. Green indicates that the target has been achieved or is on track; yellow indicates that there is progress but more effort is required; and red indicates that the programme is not on track

7.5. Discussion

Net use across countries decreases with age in children under five years (Table 17).[8,224,225] The steep decline in net use early in life is a concern for malaria prevention programmes, as these children are more vulnerable to severe malaria than their adult counterparts.

The results from this analysis suggest that the average country implementing both ANC and EPI based ITN distribution has increased household ITN ownership, increased household universal access, increased ITN use in all children under-five, and increased ITN use in children under-five in houses with at least one ITN, compared to the average country with fewer routine facility-based distribution channels. These data identify a correlation between distribution strategies implemented in a country, and ITN ownership and use for children under five. While these results cannot definitively identify causation, they may suggest that the combined impact of these two facility-based distribution strategies together far surpasses the benefit of ANC-based distribution alone.

Many studies have found ANC to be a useful and/or cost effective ITN delivery strategy.[73,74,80,84,86,98,101–104,108] A few studies define ANC and EPI based distribution as the same thing, referring to them collectively as "facility-based distribution", without differentiating between them.[106,110] But this is the first study looking at the cumulative effect of ANC and EPI-based routine distribution compared to the singular effect of just one. One important function of ANC-distributed ITNs is "catch-up and keep-up": the idea that between campaigns, ANC nets maintain ITN coverage as older nets fall out of use.[73,226] This theory may not take into account the fact that in households with pregnancies and births, the household size is increasing, so a "keep-up" strategy might replace used net, but may not be sufficient to provide additional ITNs to cover the growing household population. Countries providing ITNs via both ANC and EPI are providing additional nets for the increased household size resulting from births as well as ensuring there are enough nets for household members in-between campaigns. This may be why there is such a difference seen between the average country with both policies, compared to the average country with only ANC-based distribution.

Most efforts to increase household ITN ownership have focused on mass-distribution campaigns. While routine facility-based distribution has been seen as an appropriate way to "keep-up".[73] Mass campaigns are an essential tool for increasing ownership of ITN for vector control, but these findings show that routine facility-based distribution can also be used to increase household ITN ownership. Not only does household ownership, and household universal access, improve with ITN distribution through both ANC and EPI (Table 18), but there is also an increase in under-five children's ITN use (Figure 21). On a population level, the proportion of total children sleeping under ITNs increases with the addition of an ITN distribution policy through EPI. But more interestingly, even in households with one net, ITN use among under-five children is higher in countries with both ANC and EPI distribution (Figure 21). This may be a result of health facility training and behaviour change messaging that comes with a policy to distribute ITNs via EPI. Even if ITN availability is not consistent through these channels,[216] health workers gain training and implement messaging about net use in infancy, which may be enhanced in countries with EPI-based distribution.

The benefits of ANC-based distribution seem to decrease as children age, but the added benefit from EPI-based distribution increases as children age (Table 19). This may be the

result of ANC-distributed ITNs wearing out by the time children reach older ages. If ITNs are expected to last for 3 years, on average,[227,228] a child of 3 or 4 years of age is more likely to have a usable ITN if it was given to them within their first year of life, than if it was given to their mother almost one year before birth.

This analysis is not without limitations. Understanding the consistency and extent of routine facility-based distribution programmes through ANC and EPI is challenging. There are limited data available on national programme implementation, and there may be inconsistencies in reporting to WHO.[216] In countries with active facility-based distribution, research suggests that ITNs may not be available for the majority of women and children attending these services.[216] And, while pooled analyses and summary findings have been presented, there is diversity in national ITN coverage and use, within each distribution policy category, especially between countries with no routine facility-based distribution. There is also likely significant heterogeneity within one country (regionally, or in urban vs rural areas), in terms of how these policies are implemented and the impact of the policies on ITN use. It would be interesting to evaluate one national programme and compare ITN use within households that did and did not receive a net through these channels, but data on net source is not currently available in the DHS.

For countries with only an ANC distribution policy, Nigeria serves as a significant outlier. Net ownership in Nigeria is very similar to that in other countries in this category, but net use in children under-five in Nigeria is significantly lower. For the pooled estimates, presented in Figure 23 and Table 19 the low net use in the "Only ANC distribution" group is partially the result of the low ITN use in Nigeria. The equal weighting given to all countries ensures that Nigeria is not overpowering all other countries in the group, but its low ITN use may still misrepresent the added benefit of ANC-based distribution policies alone. There were no countries with EPI based distribution but not ANC based distribution, making it impossible to compare the two programmes individually.

If, alternatively, the analysis had been weighted by population size, Cameroon and Ghana would have been the largest weights in the category of countries without facility-based distribution. These two countries would have increased the average net use for this category. Conversely, for the category of countries with ITN distribution through ANC only, Nigeria's large population would have dramatically lowered the pooled point estimates for this category. Finally, the category of countries with ITN distribution through both ANC and

EPI would have had an increase in the impact of the policy on net use as a result of the populations of DRC, Kenya and Tanzania pulling a weighted average towards 80% ITN use in children under five years.

This analysis considered country level patterns in net use based on country self-reporting of policies to WHO. In order to understand the added benefit of ITNs distributed through ANC vs EPI on an individual or household level, it would be interesting to look at ITN ownership within countries, and compare households and families that did and did not receive ITNs through these channels. Unfortunately, the DHS does not currently collect information on ITN distribution via ANC and EPI, for analysis, making that type of analysis impossible at this time.

It is also worth noting that, while the three categories of countries were not markedly different in terms of the ALMA score card, there may be other national malaria programme or implementation characteristics which contribute to the performance of those countries with both ANC and EPI based distribution policies. The logistic analyses controlled for household size and maternal education between countries, but broader programmatic or implementation strengths were not available as potential confounders within the DHS dataset. More consistent and robust data on these channels are needed to understand fully the impact they have on ITN ownership and use.

Many countries are still lacking any policy or active distribution of LLINs via ANC and EPI programmes despite WHO recommendations for routine distribution through these channels.[216] These findings suggest that there may be a significant benefit to ITN distribution through both channels, beyond the benefit from ANC distribution alone. Both these distribution channels can be implemented across countries, and improve ITN ownership and use.

7.6. Conclusion

As supplements to mass-distribution campaigns, ITN distribution through ANC and EPI, together, can increase net ownership, universal access, and net use in children under-five. These routine distribution programmes, when implemented together greatly improve net ownership and use, and provide nets to vulnerable children who may not otherwise be covered. A second facility-based distributed ITN, via EPI, beyond the one given at ANC, has the potential to increase the total ITNs in a household, increasing the amount of homes

with universal access, and improving ITN use in children under five. Beyond "keeping-up" ITN coverage, the combination of these services can improve coverage, which is an important tool for the control and elimination of malaria.

7.7. Competing Interests

The authors declare that they have no competing interests.

7.8. Acknowledgements

We are grateful to the Demographic and Health Survey Programme and United States Agency for International Development for making the DHS country datasets available for analysis and use.

CHAPTER 8: INTEGRATING PROGRAMMES CAN IMPROVE BOTH COVERAGE AND EQUITY: A DHS ANALYSIS OF ANC, EPI AND ITN USE IN AFRICA

Chapter 8 addresses the fifth objective of this thesis, to investigate the effect facility-based ITN distribution has on the coverage and equity of ANC, EPI and LLIN use, to identify the potential benefits and/or drawbacks of integrated delivery, in terms of coverage and equity, for each integrated programme.

This analysis was conducted using DHS data which are made publicly available by USAID for research. Like chapter 7, this chapter relied on the identification of national policies from the findings of chapter 4 to compare the equity and coverage of health programmes with and without integration. The analysis focused on ITN use for children under 5, and compared that to immunization services and antenatal care in each country (Figure 24).

Figure 24: Process elements included in Chapter 8

This chapter has not been published, but does include the LSHTM Cover Sheet for research papers included in a research thesis.

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SECTION A – Student Details

Student	Katherine Theiss-Nyland
Principal Supervisor	Paul Fine
Thesis Title	Integrating insecticide treated nets with routine antenatal care and immunization programmes: policy, practice, and coverage

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

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If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*		Was the work subject to academic peer review?	

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	The intended journal has not been decided, but both Lancet Global Health and Plos One have been discussed as potential journals for submission. An alternative journal may be identified once the paper is ready for submission.
Please list the paper's authors in the intended authorship order:	Katherine Theiss-Nyland will be the first author. The final list of co-authors has not been decided, but may include Stephen ONeill, Paul Fine, and/or Jo Lines depending on their interest and contributions when this paper is finalized for submission.
Stage of publication	**Not yet submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I, Katherine Theiss-Nyland, will be the first author on this paper. I was responsible for the study design and analysis. I also wrote the complete article, as it is presented here. The potential co-authors, listed above, supported this work as advisors, assisting with statistics and economic theories, and providing feedback on the direction of the research and the clarity of the writing.

Student Signature: [redacted] **Date:** ___20/03/2017____

Supervisor Signature: [redacted] **Date:** __20/03/2017____

Integrating programmes can improve both coverage and equity: A DHS analysis comparing ANC, EPI, and ITN use in Africa

The paper has not yet been published

8.1. Abstract

Background

Insecticide treated nets, antenatal care, and immunization programmes all provide protection against morbidity and mortality for pregnant women and children. The service delivery and distribution strategies for these programmes have differed over the last few decades. Since the early 2000s ITNs have been increasingly distributed via integrated strategies, using ANC and EPI as delivery platforms, with significant increases seen post 2011. This integration may have implications for both the equity and coverage of all programmes involved.

Methods

Twenty-five countries were included in the analysis. The most recent Demographic Health Survey (DHS) from each country was analysed. Programme coverage and programme equity were calculated for each country and compared across countries and programmes. Pooled concentration indices were calculated and compared based on the ITN distribution strategies used in each country.

Results

ITN programmes were more equitable, with the most pro-poor distribution, compared to ANC and EPI programmes. ITN integration with ANC and EPI improved coverage of ITNs, and shifted equity towards a more pro-rich distribution. EPI coverage appears to be independent of integration. Where ITNs were integrated with EPI, EPI programmes were more equitable than where they were offered without ITN integration.

Conclusion

ITN distribution integrated with ANC and EPI has the potential to improve coverage for ITN programmes while improving equity for EPI and ANC. While the ITN programme shifted towards a more pro-rich distribution when integrated, it was still highly equitable, and saw

major gains in coverage. EPI and ANC programmes did not lose any coverage from integration and EPI significantly gained in equity.

8.2. Background

Insecticide treated net (ITN) distribution, the expanded programme on immunization (EPI), and antenatal care (ANC) programmes all target diseases or conditions responsible for significant morbidity and mortality, especially in Africa. These programmes aim to reach all pregnant women (ANC), infants (EPI), and people (ITNs) in communities where they are implemented, regardless of wealth or social status. Achieving equity in these programmes is not only socially or morally responsible, but it is an important disease prevention strategy.[229] Significant disease burden is concentrated among the poorest individuals within communities and countries.[229–232] Measuring programme equity can provide insights into the strengths and weakness of programme delivery, and help guide future improvements.[230,233]

One strategy for measuring equity is the concentration index. Concentration indices are based on the Gini coefficient, but unlike the Gini which plots the cumulative wealth against the cumulative percentage of population ranked by wealth, in a concentration index a cumulative measure of health is plotted against the cumulative percentage of population ranked by wealth.[184] The concentration index can be used to illustrate the degree to which the programme's coverage is concentrated within the most wealthy (or poor) households within a population, and produces a single score ranging between -1 and +1.[184] A score below zero indicates a programme in which the coverage favours the poor, or "pro-poor". A score above zero indicates a programme with "pro-rich" coverage. A score of zero would be coverage that is perfectly equitably distributed between rich and poor. These point estimates allow comparisons between different programmes and countries to understand equity across diverse settings.

Using a concentration index, Webster et al. reported that in 2005 ITN coverage in Africa was lower, and less equitable, compared to the coverage of EPI or untreated mosquito nets.[234] Prior to that research, ITNs had been distribution largely through social marketing.[234] In 2004, a Cochrane review confirmed that ITNs reduced the incidence of malaria infection by 50-62%, solidifying ITNs as a mainstay of malaria prevention efforts.[19] Malaria experts agreed that subsidized access to ITNs was important to increase ownership, but there were disagreements about the amount of subsidies and the means of

distribution.[20,235] After successful trials of ITN mass distribution campaigns in Togo and Ghana in 2004 and 2005, mass-campaign distribution became the standard for ITNs across Africa.[23,25] Further research in Kenya in 2007 found that campaigns were the most equitable distribution strategy, compared to the commercial sector or subsidized nets.[236] Between 2008 and 2010, 295 million ITNs were distributed, largely via independent mass campaigns, throughout Africa.[28]

Since 2011, the WHO and Roll Back Malaria have recommended and supported the continuous distribution of ITNs through ANC and EPI programmes in addition to mass distribution campaigns.[28,65,66,68] The intention of these routine facility-based distribution programmes is to maintain and improve coverage between mass distribution campaigns.[68,109] Despite these recommendations, national policies to distribute ITNs via ANC and EPI have developed slowly. Research analysing 38 country reports from WHO suggests that there is an ITN available approximately half of the women and less than half of children who attend these services, in countries that have a policy to distribute ITNs through ANC and EPI.[216] And of the 48 country policies that were reviewed, 11 countries had no policies for ITN distribution through ANC or EPI at all.[216]

Routine immunization services have been identified as a useful integration platform for many maternal and child health programmes.[222,237] The logic behind integration includes ease of service delivery,[60] and convenience for community members,[12,13,49] but has been influenced even more by the sustained high coverage EPI has achieved.[50,54,55,57,59,222,237] Research on the routine facility-based distribution of ITNs has focused more heavily on antenatal care (ANC) service integration, than on EPI. This research, like that focusing on EPI integration, has also found that the coverage levels sustained by ANC and EPI services are beneficial in increasing ITN coverage.[73,84,101,103,199]

The concentration index has been used to study these programmes individually. At least four studies have found that ITN distribution via campaigns is highly equitable, and often pro-poor.[98,125,135,236] And research conducted in 2016 on immunization equity in 86 countries found that the majority of low and middle income countries had pro-rich EPI programmes, regardless of coverage levels.[232] The comparative equity of these programmes, has been discussed far less. In 2005, a comparison of socially marketed ITNs and EPI found that EPI was far more equitable.[234] And research in Kenya in 2013 found that

ANC was less equitably distributed than Measles vaccination.[238] There are no published studies on the equity or inequity as a result of integration.

Considering both equity and coverage, and combining programmes with different levels of each, may prove beneficial to both programmes for different reasons. This paper describes an evaluation of the coverage and equity of ITNs, EPI and ANC. The distribution and use of ITNs by infants in Africa is explored, post 2010, and compared to the distribution and coverage of ANC and EPI in those same countries. This research also compares equity and coverage of the three programmes and aims to identify trends in either coverage and/or equity, by programme and national integrated policies.

8.3. Methods

Demographic Health Surveys (DHS) were used to calculate coverage and equity within and between countries. The DHS is a nationally representative household survey conducted every year in selected countries. The DHS includes 5,000 to 30,000 households in a given country, and collects data on a wide range of health and population topics. Surveys include questions put to all women about their most recent pregnancy, and detailed health questions for all children under 5 years of age in a household. The collected data are collated and separated into anonymized recodes for secondary data analysis. The most recent survey conducted after 2010 was included for each country in the analysis.

The children's and household data recodes were used for this analysis. The household recode includes all information about ITN ownership, as well as indicators for socioeconomic status. The children's recode includes immunization coverage for all children born in the last five years, as well as antenatal care information for the most recent pregnancy for women.

For the immunization programme, antenatal care, and ITN use, binary indicators were chosen to measure coverage. For the immunization programme, the proportion of children 12 to 24 months of age who had received a third dose of DTP vaccination (DTP3), assessed using maternal recall or written vaccination record, was chosen as the coverage indicator. While the receipt of all recommended vaccines would make is a slightly more conservative estimate, it has the challenge of potential misclassification due to polio and measles campaigns.[140–142,232] DTP3 is the most common indicator to measure progress for the EPI

programme used by WHO and UNICEF.[139] It was therefore deemed the most appropriate for cross-programme comparisons.

For antenatal care programmes, coverage was defined as the proportion of pregnant women, aged 15 to 49 who attended at least four antenatal care visits during pregnancy for the most recent pregnancy occurring within the last five years. Four ANC visits before birth is the standard recommendation for complete antenatal care delivery.[36,239] For the purposes of this analysis the timeliness of ANC or EPI was not included in the analysis.

For ITN use, the proportion of children under the age of five sleeping under a treated net the previous night was used as the coverage indicator. Ever-treated and long-lasting nets were included in the analysis; untreated nets were excluded.

Wealth quintiles within each country were used as a measure of socio-economic status. The DHS produces wealth quintile scores based on a series of household asset and household characteristic questions. Principal component analysis is used to weight and combine assets and characteristics and produce a ranking for households in each country. Households are then divided into ranked quintiles relative to wealth. This method has been validated externally, and allows for relative wealth comparisons across countries.[182,240]

Countries were categorized into routine facility-based distribution categories based on reported policies on distribution, given to the WHO as part of routine reporting on ITN distribution:[1,216] either no facility-based ITN distribution; distribution through ANC only; or ITN distribution though both ANC and EPI. All policies were set by countries before 2010.

A concentration index was calculated for each health programme in each country to obtain a point estimate of equity for a given programme. This analysis uses the Erreygers concentration index for health: E(h), which produces an absolute index with level independence, meaning that an equal increase in health across all wealth categories will result in no change in the inequality measured.[186,189,193] An absolute, rather than relative measure allows equity to be measured separate from coverage, as high coverage does not automatically imply equity.[184,186,189] The Erreygers concentration also defines the most inequitable distribution of health as one in which all of some measure of health is concentrated in the wealthiest 50% of the population.[186,189,193] This means a single individual experiencing an increase in health will shift the E(h) towards +1 if the individual is

within the wealthiest 50% of the population, and will shift the E(h) towards -1 if the individual is in the least wealthy 50% of the population. This scenario is not dependant on coverage, which facilitates the comparison of concentration indices between countries.[186]

The analysis was conducted in Stata14, using the svy and svyset commands to account for the weighted structures of national representative DHS surveys, and the conindex command for concentration indices.[241] Coverage and concentration indices were calculated for each country individually, and compared graphically, and using ranges. A pooled concentration index for each programme, stratified by ITN distribution policy was produced using a simple average where all countries were equally weighted.

8.4. Results

Insecticide-treated net coverage ranged from 6.6% in Namibia to 71.9% in Benin, with an average coverage of 42.1% for all countries weighted equally (Table 21). By comparison, vaccination coverage ranged from 23.4% in Gabon, to 97.1% in Rwanda, with an average of 73.8% (Table 21). Antenatal care had less variation than the other two programmes, ranging from 33.5% in Burundi, to 87.7% in Ghana, and an average of 57.6% (Table 21). There was no correlation found between any two programmes' coverage; high coverage in one programme did not appear to predict high coverage in another.

Insecticide treated nets were the most equitable, and pro-poor of the three programmes (Figure 25). The E(h) ranged from the most pro-poor index of -0.223 in Ghana, to the most pro-rich index of 0.179 in Burundi. There was no apparent correlation between equity and coverage for ITN use (Figure 25). The three most equitable programmes for ITN use were in Benin, Liberia and Zimbabwe, with coverage ranging from 10.4% to 71.9% (Table 21, Figure 25).

The EPI was generally more pro-rich than ITN use, ranging from -0.072 in Sierra Leone to 0.591 in Nigeria (Table 21, Figure 25). Only Sierra Leone, Uganda and Namibia had an E(h)<0 for EPI (Table 21, Figure 25). At the highest levels of vaccination coverage, approaching 100%, the E(h) could only be very equitable (Figure 25). At lower coverage levels, however, EPI was slightly pro-rich for most countries (Figure 25).

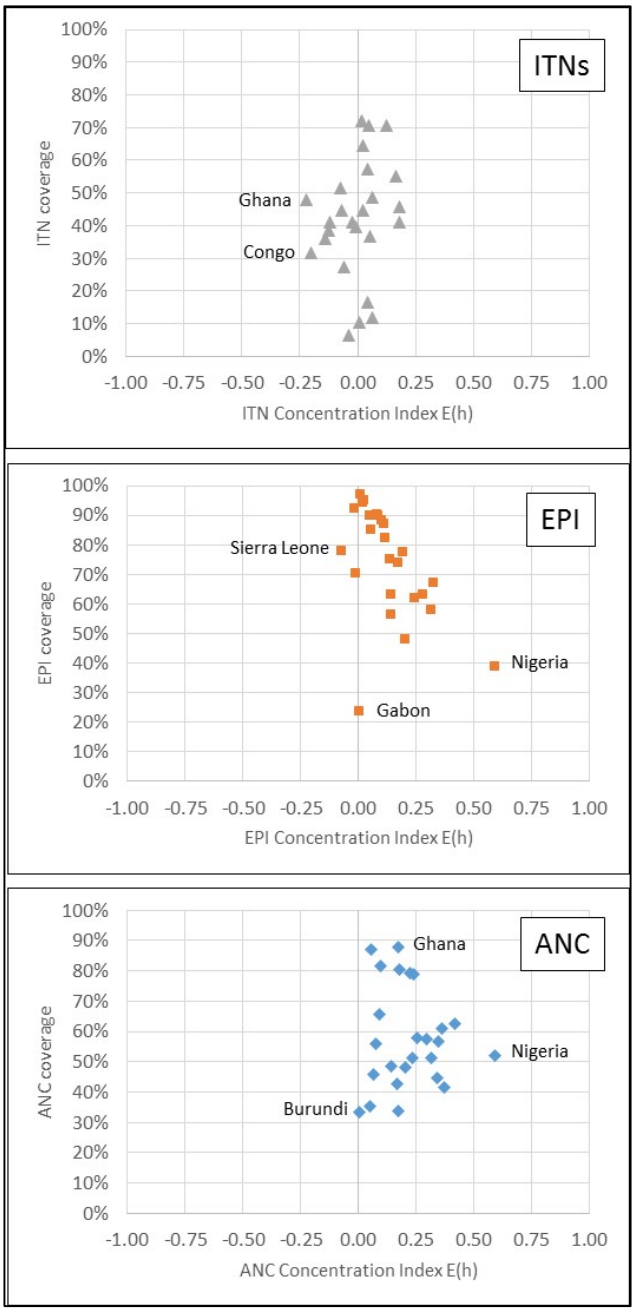
Table 21: Country coverage and Erreygers concentration index by programme

Country	ITN use (children <5 years)		EPI (DTP3 in children 12-24 months)		ANC (4+ visits)**	
	Coverage (%)	E(h)*	Coverage (%)	E(h)	Coverage (%)	E(h)
Benin (2011)	71.9%	0.016	62.9%	0.143	61.1%	0.359
Burkina Faso (2010)	48.5%	0.065	89.8%	0.087	33.7%	0.171
Burundi (2010)	45.6%	0.179	95.2%	0.026	33.5%	0.005
Cameroon (2011)	11.7%	0.064	66.9%	0.323	62.6%	0.415
Congo (2011)	31.6%	-0.201	56.5%	0.142	79.2%	0.225
Cote d'Ivoire (2012)	38.7%	-0.126	61.8%	0.243	44.5%	0.341
DRC (2012)	57.2%	0.042	58.1%	0.316	48.3%	0.202
Gabon (2012)	41.1%	-0.121	23.4%	0.006	78.9%	0.240
Ghana (2014)	47.9%	-0.223	90.0%	0.051	87.7%	0.173
Guinea (2012)	27.5%	-0.058	48.1%	0.205	56.8%	0.346
Kenya (2014)	55.2%	0.164	90.2%	0.078	57.8%	0.252
Liberia (2013)	39.5%	-0.007	73.7%	0.171	80.6%	0.178
Malawi (2010)	40.9%	0.178	94.4%	0.020	45.8%	0.067
Mali (2012)	70.6%	0.048	63.0%	0.277	41.6%	0.370
Mozambique (2011)	36.7%	0.050	77.6%	0.193	51.2%	0.232
Namibia (2013)	6.6%	-0.038	92.2%	-0.019	81.5%	0.095
Nigeria (2013)	16.7%	0.045	38.7%	0.591	52.2%	0.593
Rwanda (2010)	70.5%	0.124	97.1%	0.011	35.5%	0.048
Senegal (2010)	36.1%	-0.142	82.2%	0.116	51.2%	0.313
Sierra Leone (2013)	51.6%	-0.073	78.0%	-0.072	87.0%	0.057
Tanzania (2010)	64.5%	0.025	88.1%	0.101	42.9%	0.167
Togo (2013)	44.5%	-0.068	84.9%	0.053	57.4%	0.296
Uganda (2011)	44.7%	0.022	70.4%	-0.010	48.5%	0.141
Zambia (2013)	41.1%	-0.023	87.2%	0.111	56.0%	0.076
Zimbabwe (2010)	10.4%	0.008	75.1%	0.137	65.7%	0.089

* Erreygers concentration index for health outcomes
** Includes the most recent pregnancy for all women (both living and deceased children)

Antenatal care was the most pro-rich of the three programmes, with no countries achieving a pro-poor E(h) (Table 21, Figure 25). The most equitable ANC E(h) was 0.005 in Burundi, which was also the country with the lowest ANC coverage (Table 21, Figure 25). The least equitable ANC programme was in Nigeria, with E(h)=0.593. While very high coverage levels prevent programmes from being extremely inequitable, ANC still had strongly pro-rich programmes even when coverage levels were above 80% (Figure 25).

Figure 25: Programme coverage against concentration index for EPI, ANC, and ITNs



When countries were separated into routine facility-based distribution categories, patterns began to emerge (Figure 26). Across all countries, ANC and EPI programme coverage generally increased with the increase in wealth, with few exceptions (Figure 26). By comparison, ITN coverage was generally much more heterogeneous, and more visually equitable by wealth quintile, with both upward and downward slopes represented (Figure 26). Overall ITN coverage was generally lower than those of ANC and EPI. The countries with the greatest difference in coverage between ITNs and either ANC or EPI were

countries without any facility-based ITN distribution, such as Cameroon, Namibia and Zimbabwe (Figure 26). By comparison, eight out of the 13 countries with ITN distribution through both ANC and EPI had ITN coverage levels greater than ANC or EPI (Figure 26). Overall, ITN coverage seemed to increase with integrated ITN distribution through ANC and EPI.

ITN distribution was the most pro-poor programme, compared to EPI and ANC. Four of the six countries without any facility-based distribution had pro-poor ITN distribution, and three of those countries (Senegal, Congo, and Ghana) had the most pro-poor ITN programmes across all countries, regardless of ITN distribution policy (Figure 26). When the E(h) of all programmes was graphed, and stratified by facility-based ITN distribution policies, a clear pattern emerges in ITN programme equity (Figure 27). ITN distribution was most pro-poor in Ghana and Congo, countries without integrated distribution (Figure 27). In countries without facility-based ITN distribution the average E(h)=-0.09 (Figure 28-a). With the addition of integration through ANC and EPI, ITN distribution becomes less pro-poor (Figure 27). The E(h) increases with each additional distribution programme becoming more pro-rich when ITN distribution policies exist for both ANC and EPI (Figure 28-a, b, c). However, the most pro-rich distribution of ITNs seen in countries with ANC and EPI based integration is more equitable than the ANC or EPI programme distribution in those same countries (Figure 28-c, e, g).

By comparison, EPI programmes appeared more equitable when combined with ITN distribution (Figure 28- f, g). In countries without ITN distribution through EPI, the average EPI programme E(h)=0.17, while in countries with integration through EPI, the E(h) for EPI is more equitable, equalling 0.10 (Figure 28-f, g). There is no evidence in this analysis that ANC programme equity changed on the basis of integrated ITN distribution (Figure 28- d, e).

Figure 26: Programme coverage (vertical axis) by wealth quintile (horizontal axis least to most wealthy) for each country, countries grouped by ITN facility-based distribution policies

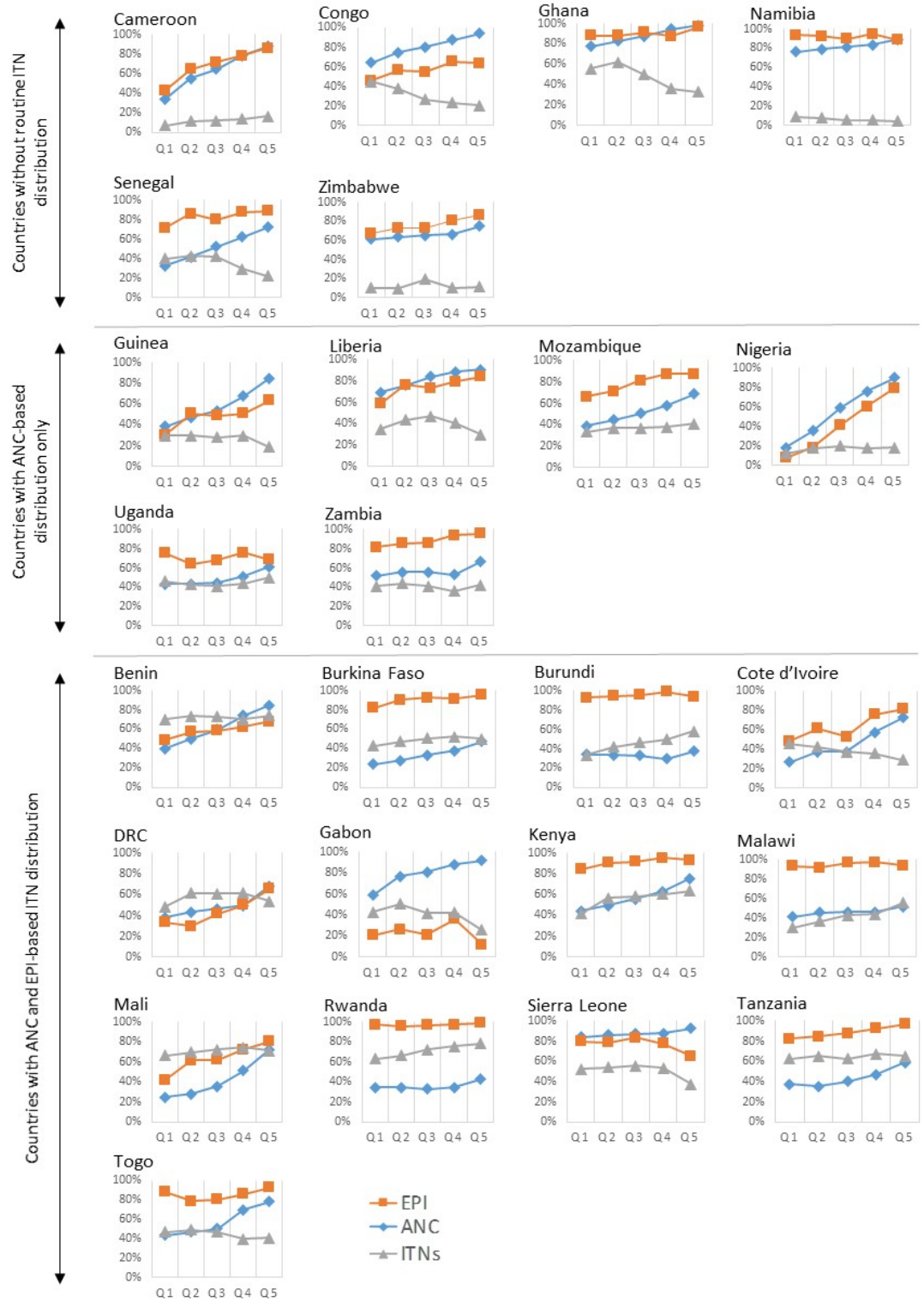


Figure 27: Concentration indices for all programmes ranked by ITN index (most pro-poor to least pro-poor) separated by national routine facility-based distribution strategy

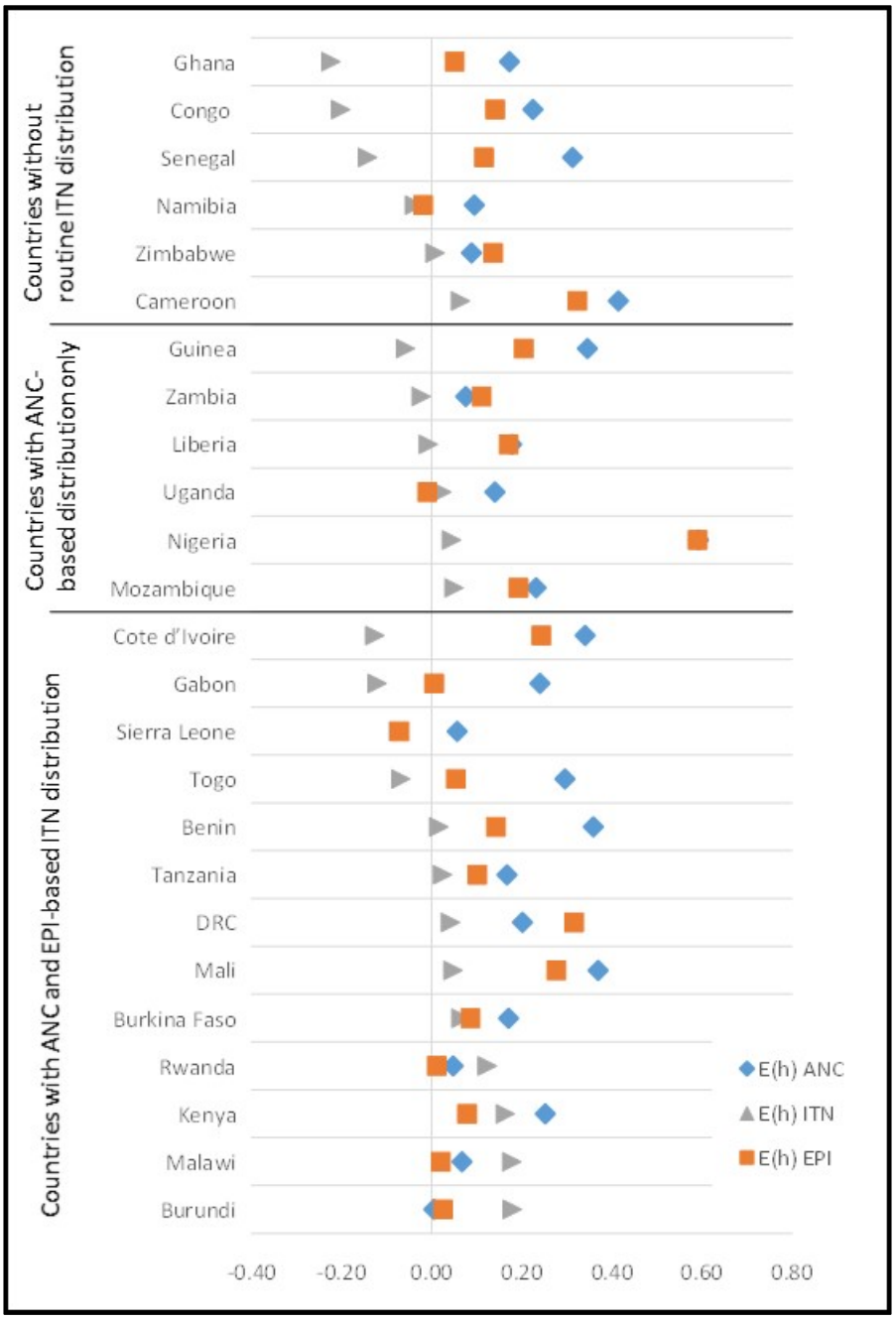
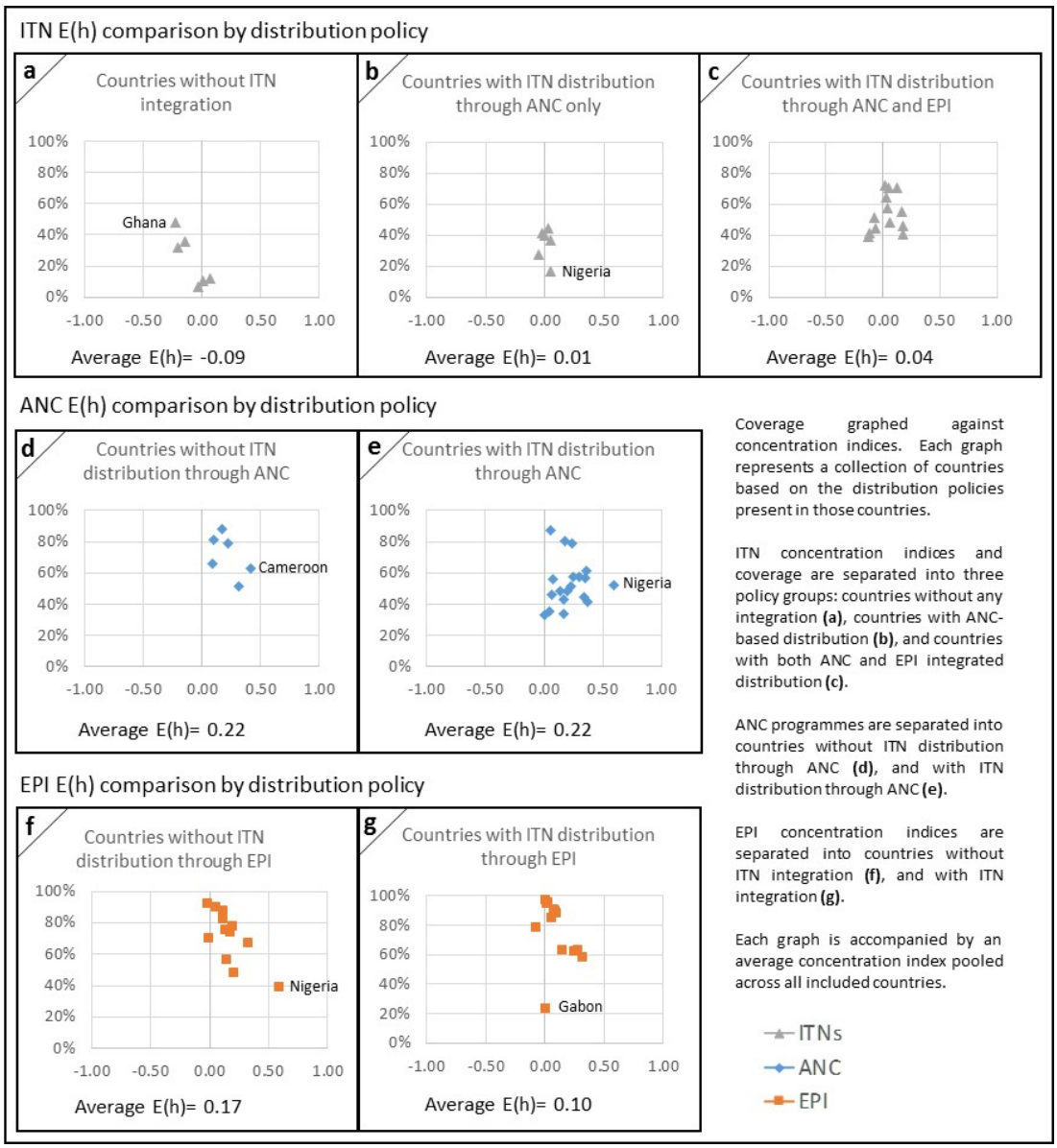


Figure 28: Coverage (vertical axis) and concentration index (horizontal axis), by programme and country policy



8.5. Discussion

Antenatal care and EPI have been used as integration platforms for other health interventions as a result of their continuous nature and their high coverage. This integration is often framed in terms of the benefit to the other health programme, with little discussion of the potential benefit to ANC or EPI.[47,237] The research presented here, by comparison, shows that while coverage of the integrated programme of ITN distribution

can benefit from integration with ANC and EPI (Figure 26), EPI can also be improved in terms of equity (Figure 28).

This research suggests that EPI programmes were more equitable, and more pro-poor when integrated with ITNs, as compared to EPI programmes that were not integrated, without any detriment to EPI coverage. The improvement of EPI equity as a result of integration with ITNs was seen in the experience of integrated ITN and vaccination campaigns in Madagascar in 2012.[242] It is likely that the same would be seen in routine distribution. Insecticide-treated nets may serve as an incentive to attend routine services, and may be used by EPI to incentivise attendance at later stages of the immunization schedule when coverage is lower. Globally, disease burden is often concentrated among the poor, and so efforts to promote more equitable or pro-poor distribution strategies can have significant benefits for disease prevention.[229–231]

The shift in ITN programmes away from pro-poor and towards pro-rich as the result of integrated distribution likely highlights the difference between campaign and routine distribution strategies. ITN distribution campaigns have proven to be highly equitable, and often pro-poor in previous research.[125,135,236] The pro-poor ITN programme experience is likely also representing a pro-rural distribution strategy employed by ITN mass distribution campaigns.[243] By comparison, routine distribution systems may be better equipped to reach populations that are urban, well connected by roads, living near to health services, and generally wealthier. Despite the pro-rich bias that may exist in routine programmes, the stability of these programmes helps to provide high coverage of their services. Countries may benefit from the highly equitable and pro-poor nature of mass distribution campaigns, and the increased coverage resulting from integrated routine facility-based ITN distribution by implementing both distribution methods consistently.

Previous research assessing the availability of ITNs through ANC and EPI suggests that integration in these channels was not complete and still has significant missed opportunities for ITN distribution in many countries.[216] If facility-based ITN distribution were scaled up to meet the need presented in ANC and EPI, further improvements in ITN coverage and ANC and EPI equity might be seen.

There is no evidence here that ANC programmes experience improved equity as a result of ITN integrated distribution. This is likely due to the fact that “at least four” ANC visits was

used as the chosen indicator, while ITN distribution occurs at the first ANC visits. As a result, the availability of ITNs are unlikely to impact subsequent ANC visits. There were only 6 countries without ANC-based ITN distribution, as compared to 19 countries with ANC-based ITN distribution, making the comparison limited. Nigeria has the most inequitable ANC and EPI programmes, by far. If Nigeria is excluded, the average ANC programme E(h) in integrated countries becomes more equitable. There was no reason that Nigeria should be excluded, however, and is in fact the largest country population, representing the experience for a very large number of women and children in Africa.

Countries were categorised into policy categories based on crude country reports to WHO, to investigate equity as a result of integration. It would be interesting to look at ITN distribution within one country, and assess if ITNs distributed through ANC and EPI are less or more equitable than those distributed via mass distribution campaigns. At this point in time, there are no routine data available to allow this kind of assessment. The DHS data do not include information on the distribution channels within one country, making that type of analysis impossible. This analysis uses cross-sectional survey data, so there is no way of comparing programme coverage and equity before and after integration has occurred. There may be other programme differences that are responsible for the equity and coverage of programmes, such as ITN distribution campaigns, for example, that are unrelated to integration. Due to the limitations of the DHS data, these other strategies were not included.

8.6. Conclusion

The integration of ITN distribution through ANC and EPI has the potential to benefit all the programmes involved, not just ITNs. By considering both coverage and equity as goals of programme distribution, integrated ITNs can support improvements in programmes like EPI, that have traditionally high coverage on their own. ITNs, by comparison, can gain coverage through integration, but may lose some pro-poor programme coverage through the integration with programmes that are more pro-rich overall, like EPI and ANC.

Integration can improve convenience for community members, and increase coverage and equity for the integrated programmes. To more accurately understand the dynamics of integrated programmes more data on ITN distribution channels and coverage via these channels are required.

8.7. Competing Interests

The authors declare that they have no competing interests.

8.8. Acknowledgements

We are grateful to the Demographic and Health Survey Programme and United States Agency for International Development for making the DHS country datasets available for analysis and use.

CHAPTER 9: DISCUSSION

This project set out to evaluate the policy and implementation of routine facility-based distribution of ITNs via ANC and EPI, as well as to assess the state of ITN ownership and use as a result of these distribution channels. Using mixed methods, including qualitative programme evaluations, quantitative DHS analysis, and the application of health economics methods, this project evaluated the distribution of ITNs via ANC and EPI. The analysis focused on international recommendations, national policies, facility distribution, and individual access and use of ITNs. In this chapter, the findings of the five results chapters will be brought together, and key cross-cutting results will be presented. The limitations of this project will be presented, the findings will be put in the context of other research, and recommendations for future work will be offered, based on these findings.

9.1. Synthesis of findings

The comparison of ITN use among children in countries with and without routine facility-based distribution (chapter 7) showed that there may be major benefits to malaria prevention efforts as a result of the implementation of such policies. Household ownership of ITNs is higher in countries implementing facility-based distribution through ANC and EPI, as compared to countries without these programmes. Countries with routine facility-based distribution also have a larger proportion of children using ITN, on average, as compared to countries without these programmes. More specifically, both ITN ownership and use increase with the addition of each facility-based distribution programme, resulting in the highest ITN ownership and use seen, on average, in countries with both ANC and EPI-based distribution channels, compared to countries with only ANC-based distribution, or countries with neither. The distribution of ITNs via ANC and EPI does more than maintain coverage, as has been expected. These results suggest that routine facility-based distribution channels may increase ITN coverage and improve ITN use in children. This increase in ITN use in children as the result of routine facility-based distribution programmes may be due in part to targeted messaging and education that accompany this distribution channel. Facility-based ITN distribution through ANC and EPI targets pregnant women and children, and health care workers are likely focusing their education and messaging on the use of ITNs by these target groups, at the time of distribution.

ITN coverage was lower, on average, than ANC and EPI coverage across countries, but was more equitable, with an E(h) score closer to zero, or more pro-poor, with a negative E(h) score, than the other two programmes (chapter 8). In countries with ITN integration, ITN programmes had higher coverage than in countries without integrated programmes, suggesting integration may improve ITN coverage. But, the analysis in chapter 8 suggests that ITN programmes were also slightly less equitable and more pro-rich in countries with integration, with more E(h) scores above zero, as compared to those countries without integration. ANC, and EPI, by comparison had E(h) scores higher, and farther away from zero, suggesting that they were less equitable and more pro-rich, on average, than ITNs. EPI programmes were more equitable, on average, with E(h) scores closer to zero, when integrated with ITNs. ANC, by comparison, was no more equitable with ITN integration than without. ITNs are integrated into the EPI schedule at different points in different countries, and given to children at various ages, depending on the decision made by the country programme. In principle, ITNs may be distributed at several different ages between birth and 9 months of age, depending on the schedule in each country, as part of EPI. The improvement in equity, associated with integration, may be a result of more children completing the EPI schedule, especially when the ITN distribution is integrated at a later stage, as a result of the incentive that the ITN represents. By comparison, in every country, ITNs are always integrated with the first ANC visit, for pregnant women. The proportion of women attending at least one ANC visit is extremely high, on average, and the ITN will likely have no effect on future ANC visits at which there may be decreasing uptake by the poor, due to the time and energy needed to return for subsequent ANC visits.

Despite these benefits to ITN ownership, ITN use, ITN coverage, and EPI equity, policies to integrate ITN distribution with ANC and EPI have not been widely implementation across Africa. Many countries have yet to create a policy and implement routine facility-based distribution of ITNs, despite WHO recommendations. Of those countries that have implemented facility-based ITN distribution via ANC and/or EPI, the number of ITNs reported to be available for distribution is dramatically fewer than the number of women and infants attending these services, for whom an ITN should be made available (chapter 4). Further, despite the theoretical demand for ITNs via ANC and EPI being nearly identical (for each pregnant woman there is a corresponding infant), there are nearly twice as many ITNs distributed via ANC as there are distributed via EPI. This is unlikely to be due to a

difference in ANC and EPI coverage, as EPI and ANC have comparable coverage, on average. Further, nearly twice as many ITNs are needed via these two channels combined, than are currently made available, to reach the women and children in the countries where facility-based integrated ITN distribution is already policy. A significantly larger number of ITNs would be needed if all malaria endemic countries in Africa were to implement facility-based routine distribution of ITNs, in line with the WHO recommendation.

In four countries that have the policies for ITN distribution through both ANC and EPI, and are actively implementing both, operational challenges to these distribution channels were identified during the qualitative study (chapter 5). The evaluation indicated that the training of staff on the routine distribution of ITNs via ANC and EPI was underfunded, and implemented far less often than national and regional malaria programme staff would have liked. The national quantification exercises, to calculate the total ITNs needed in each country per year, did not consistently consider reported service delivery at the facility level. But, most noticeably, stock-outs were reported in all health facilities visited during the qualitative study. At the facility level, health workers reported stock-outs of ITNs regardless of the frequency of ITN resupply. Further, there were no systems in place in any of the four countries visited to report and remedy stock-outs in-between planned resupplies. Some facilities created unofficial ITN sharing plans with other facilities to spread out supply, or called the district to request more ITNs, but most often, health workers reported having to wait for the next supply, with no ability to formally re-order ITNs when there was a stock-out. Stock-outs were not only an issue at facility level. Regional and national malaria health and logistics officers reported stock-outs of ITNs, and an inability to meet the supply demands of lower level service-delivery facilities. At the national level, despite commitment to these distribution channels, national malaria control programme staff reported difficulty in consistently maintaining ITN supply levels at health facilities, necessary for the implementation of these programmes. This was reportedly due to inadequate or unreliable consumption estimates at lower health system levels, which hindered the national programme ability to accurately estimate the country ITN need. Given the findings in chapter 4, discussed above, these stock-out and supply issues are not surprising.

Beyond the operational challenges to facility-based ITN distribution, there are clear differences between ANC and EPI as service delivery platforms for integration (chapter 6).

During the qualitative assessments, ANC programmes were characterised by respondents as diverse collections of health interventions and monitoring tools, and ITNs were often described as part of the ANC routine care checklists and programme policies within countries. ANC staff reported ITN distribution as one of many ANC components necessary for complete ANC service delivery. By comparison, EPI programmes were focused on the delivery of vaccinations to children under one year of age. At the national level, EPI programme officers were supportive of the idea of integration, but they were not interested in monitoring or overseeing interventions that were not vaccines. Even when health facility staff had manually created an extra column in the vaccination log-books to record ITN distribution, this information was never consolidated and reported to higher levels of the health system as part of EPI monitoring.

These findings from chapter 6, which described the differences between ANC and EPI as integration platforms can be explained, to some extent, by the differences in guidelines and recommendations produced by international ANC and EPI partner organizations. While both ANC and EPI have produced documents and recommendations promoting integrated maternal and child health services,[31,37,44] ANC has included malaria prevention as a key feature in many of its regional guidelines on ANC service delivery.[37,44] By comparison, EPI service delivery guidelines do not consider non-vaccine interventions, and only provide information on vaccine delivery.[29] Likewise, the WHO vaccine schedule optimization programme does not consider the scheduling needs of non-vaccine interventions when assessing appropriate EPI schedules.[244] EPI programmes have been very successful, historically, at achieving high immunization coverage, focusing solely on vaccines. This has likely led to a programme hesitancy to expand to broader programmes (such as ITNs), for fear that a larger list of interventions may distract from the implementation of core programme vaccines. The EPI approach, to focus on the antigen-specific vaccine delivery, is understandable, but these types of approaches may unintentionally contribute to the lower number of ITNs available for infants than for pregnant women, identified in chapter 4.

Across both ANC and EPI programmes, there is a common concern that the addition of multiple interventions may at some point lead to the over-burden of health care workers, which will lead to a decrease in the delivery and performance of the programmes overall. Balancing the need to deliver multiple interventions, with the challenge of under-staffing

and limited time available with each family is a practical programme implementation concern without a clear solution.

Even accounting for the "in-country" and programme-specific challenges to facility-based distribution, the international funder systems that do not prioritize these distribution channels, despite WHO recommendations, are likely the broader reason for the under-supply of ITNs via ANC and EPI across Africa. The vast majority of ITNs distributed in Africa are funded by the Global Fund, based on country grants. Between 2003 and 2015, 659 million mosquito nets were distributed as a result of Global Fund funding.[3] In order to gain Global Fund funding, countries apply to Global Fund with proposed interventions and budgets for HIV, Malaria and TB programmes. In order for countries to continue to receive support from the Global Fund, several monitoring indicators are used to track country progress. To monitor the routine distribution of ITNs via ANC and EPI, the Global Fund includes the "proportion of targeted risk groups receiving insecticide-treated nets (pregnant women, children under 5)" as a core indicator.[245] The Global Fund provides indicator guidance to assist countries in calculating coverage archived, by detailing what numerator and denominator to report. However, in the indicator guidance sheet for countries calculating the indicator for routine facility-based ITN distribution, the Global Fund requests the "number of ITNs distributed to target groups through ANC and EPI", and lists the denominator as "not applicable" (Appendix E), meaning that countries are not required to report the unmet need for ITNs through these channels.[245] Instead, the template for calculation asks for the planned distribution compared to actual distribution, with no mention of the total population attending these services or in need of distribution.[245] (By comparison, ITN ownership and ITN use calculations for the Global Fund require denominators of the total number of households, and total population, respectively, seen in Appendix F.) As a result, countries are dis-incentivized from listing the target as the true need (the number of women and children attending ANC and EPI), in favour of a more achievable and lower target, which will help countries to appear high performing and secure further funding.

This problem is compounded by the fact that between 2010 and 2013, due to corruption resulting in financial short-falls, the Global fund restricted funding, and specifically disallowed the introduction of new interventions as part of funding applications.[246] This change overlapped with the new WHO recommendation, in 2011, to include facility-based

ITN distribution via ANC and EPI. The Global Fund restructured in 2013 and garnered new global commitment with the assurance that countries would do more with less, and develop self-reliant funding streams.[247–249] Countries planning to implement the additional programme of routine facility-based ITN distribution via ANC and EPI, are under more pressure to find funding in the budget without significantly increasing the total requested budget.[247–249] As a result, countries are likely to either request an under-supply of ITNs for this programme, or request an appropriate supply and be denied other funding. By limiting funding for these new distribution channels, and not requiring national programmes to be accountable for distributing ITNs to all women and children attending ANC and EPI, the Global Fund is making a statement that these types of distribution services are not a priority.

All of these results, from the five results chapters together, lead to a few broad findings:

- Despite the incomplete implementation of ITNs via ANC and EPI, resulting in large missed opportunities, routine facility-based ITN distribution is strongly correlated with higher ITN ownership and use, in countries implementing these distribution channels, compared to countries that are not.

- If these programmes were scaled-up to reach all of the women and children attending ANC and EPI, significantly more ITNs would be needed, and one might expect the resulting ownership and use of ITNs to be even greater.

- Despite the possibility that ITN distribution via EPI may also improve the equity of EPI programmes, there is less interest shown at the national and international level in integrating the management, monitoring and evaluation of ITNs within EPI, which may contribute to the lower numbers of ITNs distributed via EPI as compared to ANC.

- For those countries actively implementing these services, there are a number of operational challenges which may be preventing the effective distribution of ITNs, including limited training for health facility staff, stock-outs, and non-existent stock re-supply systems.

- The monitoring and evaluation of ITNs distributed via ANC and EPI is particularly lacking in countries implementing these programmes, with little routine service delivery data available to monitor the reach and saturation of these programmes.

- To alleviate stock-shortages and supply challenges that were reported at the national level in countries with these programmes, at the international level funders should support a supply chain that provides enough ITNs for all the women and children attending these services.

9.2. Limitations of this research

Overall, the main limitation of this project was the lack of routine service delivery data, or nationally representative cross-sectional data, on the routine facility-based distribution of ITNs. This means that there are no data available that link service delivery and distribution to ITN ownership and use. Without such data, it was difficult to assess the extent to which these ITN delivery channels have reached the target populations that they are designed to serve. As a result, it was necessary to use a variety of data sources and methods to assess routine facility-based distribution from different angles, to evaluate policy, implementation and coverage. Had there been routine ITN distribution data available, detailed analyses could have been conducted to clarify the current state of these programmes.

Throughout this project, countries were classified into routine facility-based ITN distribution categories based on national ITN distribution reported to WHO by national malaria control programmes. These classifications, originally introduced in chapter 4, are crude, and do not take into account the quality or intensity of the distribution programmes, masking any heterogeneity in implementation between countries in each category. In chapter 4, the analysis of ITN availability compared to ANC and EPI attendance found that routine facility-based ITN distribution is incomplete, with significant missed opportunities for ITN distribution to women and children attending these services, in countries implementing these policies.

In chapters 7 and 8, these same categories, identified in chapter 4, were used to highlight the potential impact on coverage achieved through routine facility-based ITN distribution. Chapters 7 and 8, which look at individual ITN ownership and use, primarily use DHS datasets. Unfortunately, it is not possible with the current survey questionnaire and

recodes to identify the sources of an ITN, or to identify women and children who had received an ITN through ANC or EPI services. Given this limitation, entire countries were categorized as having or not having facility-based ITN distribution, and ITN ownership and use was compared at the country level. The resulting coverage outcomes can only be described as a correlation, and cannot be attributed causally to the distribution programmes. Further, information was not available in the DHS about the frequency or success of mass ITN distribution campaigns. As a result, the analyses in chapters 7 and 8 did not take campaigns into account. As campaigns are a commonly used ITN distribution strategy, the assumption was that the major differences between countries was not campaigns, but integrated routine ITN distribution through ANC and EPI, however this could not be tested.

The impact of ANC and EPI-based ITN distribution on ITN use among pregnant women was not included in the DHS analysis because of the large literature that already exists on the subject of malaria in pregnancy. The decision was made to focus on children under five, throughout this project, because less research, by comparison, focuses on this vulnerable group. A comparison of these groups, however, could provide additional information about the relative benefit these programmes have on the targeted recipients (pregnant women) compared to the broader recipients (children under 5).

Outside of the facility-based ITN distribution policies, it is important to recognize that there may also be multiple competing, and potentially confounding, factors associated with ITN coverage and use in countries with and without routine facility-based ITN distribution. Most notably, the countries that have chosen to implement routine facility-based distribution of ITNs may be the same countries with strong malaria control programmes, in terms of policies, staffing, resources, and ITN distribution programmes. These countries may have more capacity to handle the increased number of distribution channels that result when adding routine facility-based distribution. The higher coverage identified in these countries may be the result of strong national malaria control programmes, and effective malaria prevention strategies as a whole, and not just the specific effect of routine facility-based ITN distribution. While effort was made to identity this potential confounder, using the country ALMA scores in chapter 7, these findings were not definitive, and there may still be confounding that was not identified or measured.

The resources a country has dedicated to ITN distribution may be a greater influence on the overall coverage and availability of ITNs and the success of integrated distribution channels, than other policy decisions. In resource limited settings, campaign-based ITN distribution may be the most feasible and equitable option available. As a result, countries with limited resources may also have limited distribution policies, which would confound the results of this project. As programme resources were not available to analyse, there was no way to disentangle these data in this project.

In chapter 5 the operational challenges to integrated ITN distribution were evaluated. One of the key differences between some countries is the role of partner organizations in the implementation of ITN policies, and the distribution of ITNs. In all four countries included in the qualitative work presented in chapter 5, partner organizations, supported by the Presidents Malaria Initiative, were involved in these programmes. This country selection meant that it was not possible to compare countries with and without strong partner organization involvement. Countries without these partner organizations supporting ITN logistics may have a very different experience with coverage and stock-outs. These experiences could not be analysed in this project.

In chapters 5 and 6 the qualitative tools used for data collection were reviewed by senior members of the malaria control programmes in each country before being implemented. As a result, national programmes were able to influence the type of data collected as part of this project. While no major changes were made as a result of these reviews, at the national level, senior staff were aware of the type of programme questions included, and could subsequently prepare for the interviews.

Despite these limitations, and the detailed limitations of this research project presented in the discussion section of each chapter (4.5; 5.5; 6.6; 7.5; 8.5), countries across Africa are continuing to develop policies for, and to implement, routine facility-based ITN distribution. The findings from this project can help countries considering these distribution channels to think through the challenges they might face, the monitoring and evaluation tools which could be implemented, and the results they might expect.

9.3. Findings in the context of other research

Prior to this project, there had not been any research estimating the scope of routine facility-based distribution in Africa. The results from chapter 4 were included in the 2013 World Malaria Report, as the first estimation of the reach of routine facility-based distribution, as well as the missed opportunities to provide ITNs to women and children attending ANC and EPI services.[1] A similar analysis was presented in the 2016 World Malaria Report, updating those findings from 2013, which found that the availability of ITNs via ANC and EPI has not improved as compared to the analysis presented in chapter 4. Specifically, in the 2013 World Malaria Report, and chapter 4, analysis showed that there were ITNs available for only 55% of women attending ANC, and 34% of children attending EPI, in countries with routine facility-based ITN distribution policies and implementation.[1,216] The World Malaria Report in 2016 reported ITNs available for 39% of women attending ANC and 20% of children attending EPI, in Africa, in the years 2013-2015.[2] While this might suggest that facility-based ITN distribution has decreased, the 2016 World Malaria Report findings included all malaria endemic countries in Africa, not just those implementing routine facility-based distribution policies.[2] As a result, it is impossible to disentangle to what extent the ITN availability through these channels is the result of poor distribution channel performance in countries with policies, or the lack of policies in malaria endemic countries.

The operational research presented in this project aligns with the findings of previous qualitative field assessments of malaria prevention integrated with ANC and EPI services. A study by Wallace et al. in Mali and Cameroon also found that the number of forms and reports was a challenge for health workers delivering integrated child services, including ITNs integrated with EPI programmes.[105] Two qualitative studies in Mali evaluated ITN and IPTp delivery through ANC services. While these studies focused primarily on IPTp, there were important barriers to ITN distribution identified. Similar to the findings presented in Chapter 5, they found that stock-outs were the most common barrier to consistent ITN delivery, when integrated with ANC.[101,104,197] In Mali, Cameroon, and Ethiopia, Ryman et al. evaluated integrated child health and also found that ITN stock-outs were the greatest concern raised by health workers for ITN distribution.[60]

At least two studies and three models have looked at ANC and EPI-based ITN distribution combined. The bulk of these, however, made no distinction between either the implementation or impact of these two programmes, separately or comparatively.[106–108,110] The research presented here, in chapters 4 and 6, demonstrates that the current state of these policies, the implementation of these programmes, and the coverage outcomes achievable through these programmes may differ as a result of the platform used for integration (ANC or EPI). One model, by Okell and colleagues, did find that ITNs distributed via EPI could prevent more child mortality than ITNs distributed via ANC.[109] It was not possible to look at EPI-based ITN distribution independently in the research presented in this project, because there were no countries implementing EPI alone. But the DHS analysis presented in Chapter 7 supports the prediction in the previously mentioned model by Okell et al., demonstrating that ITN use among children was higher in countries with both ANC and EPI-based ITN distribution, compared to countries with ANC-based distribution alone.

Previous research is inconclusive with regard to the subsequent spread and use of ITNs distributed via ANC and EPI, amongst the non-targeted population. Two studies published in 2011, by Skarbinski and O'Meara, assessing ITN ownership and use in communities with only facility-based ITN distribution via ANC and EPI, found that households with women and children were the most likely to have ITNs, but that ITNs from ANC and EPI were also found in other households.[106,107] The modelling tool, NetCalc, used to predict coverage as a result of combined distribution strategies, assumes perfect community redistribution so that any ITN distributed will be used for individuals in need, regardless of the distribution channel targets.[250] By comparison, a paper by Koenker et al., also using NetCalc, cautioned that attention must be paid to the overlap of households targeted by multiple distribution channels, which could decrease the observed impact of the channels when combined.[110] Carlson et al. went further on the basis of another model, concluding that the combination of ANC and EPI-based ITN distribution resulted in significant overlap of targeted families, and therefor EPI-base distribution was only able to provide incremental gains beyond ANC distribution alone.[108]

The research findings presented in chapter 7 align with the findings from Skarbinski and O'Meara, as well as the assumptions built into NetCalc.[106,107,250] ITN ownership within the whole population, in countries with both ANC and EPI policy, was significantly higher than

ITN ownership in countries with only ANC-based ITN distribution, or no facility-based ITN distribution. Notwithstanding the confounding issue discussed above, this supports the idea that ITNs are shared within communities and reach households in need, with or without pregnant women and infants.

Further, chapter 7 findings show that infant ITN use is higher in countries with both ANC and EPI-based ITN distribution, compared to countries with ANC-based distribution alone. Much of the previous research on ITNs distributed, via ANC alone, proposes that these ITNs will be used by both pregnant women and their new-born children after birth.[80,82,87] While women often share ITNs with their children, these statements fail to consider the average ITN lifespan when considering malaria prevention for children under 5. An ITN is estimated to last an average of 2 or 3 years, depending on the analysis.[227,228,251] If an ITN is given to women 6-8 months before they give birth (during the first ANC visit), the ITN will no longer be effective, on average, when the new-born child reaches 3 years of age. As previously stated, the model by Okell did note that EPI-based ITN distribution would prevent a greater number of deaths in children under 5, as compared to ANC-based ITNs, due to the age distribution of mortality risk for children.

Much of the previous research has not recognized the fact that as children are born into families, the total population of the household increases, and as a result, the total number of ITNs needed to cover all household members also increases. The models used to assess ITN need and effective distribution channels, such as NetCalc, often incorporate average household size, but do not consider the changing household size as the result of births.[110,250] These models have likely underestimated the combined effect of ANC and EPI distribution because they have not considered the growing household size, and the average lifespan of an ITN, in combination.[108–110] The research presented here, by comparison, finds that the combined effect of ANC and EPI-based ITN distribution is much greater than that of ANC-based distribution alone, which is likely due to both the growing size of households and the average lifespan of ITNs.

The findings in chapter 8, on the inequity of ITN, ANC and EPI programmes with and without integration are difficult to compare to other studies on equity because of the variety of concentration indices in use within public health research. In 2005, Webster et al. published a study evaluating the equity of ITN ownership, compared to never-treated

bed-net ownership, and EPI services. At the time of this study, ITNs were not distributed free of charge, but were instead distributed via social marketing which provided ITNs to target communities at reduced prices. Untreated nets, by comparison, were manufactured locally, and sold in local markets.[234] This study found that ownership of socially marketed ITNs was the least equitable, and the most pro-rich, while EPI was the most equitable of the three.[234] The results presented in chapter 8, by comparison, found that ITN ownership was very equitable and the most pro-poor, compared to EPI and ANC. These results highlight the value that free mass-distributed ITN programmes have had in improving the equity of ITN ownership in Africa. However, because Webster et al. used a Wagstaff concentration index, W(h) the estimates cannot be directly compared. In 2012, Barros et al. published a comparison of the equity of different maternal and child health programme coverage in low and middle-income countries. This research included analysis of ANC, EPI and ITN programme equity, and found that ANC was the least equitable and pro-rich, and EPI was the most equitable.[252] This study, however, used the unadjusted concentration index for health C(h) which is highly dependent on coverage levels, making direct comparisons between its findings and those presented here inappropriate. The findings from chapter 8 do align with these two studies in finding that EPI has higher coverage than ITNs, and is an equitable programme overall, with a concentration index score close to zero when measured on a Wagstaff, Erreygers or traditional C(h) scale. More consistent integration of ITNs with EPI and ANC may help to improve the coverage of ITNs, without a detrimental effect on equity.

9.4. Implications and recommendations for future research and action

As shown in the introduction, previous research has established that routine facility-based distribution of ITNs via ANC and EPI is feasible,[74,80–82] cost-effective,[80,85–87] and well received by both health workers and community members.[47,60,83] Many more recent publications have focused on identifying which types of continuous distribution programmes (such as school-based, or facility-based, for example) are most useful for different countries.[110,250,253] Despite the variety of continuous distribution options, the WHO recommends ANC and EPI-based distribution for all malaria endemic countries, and many African nations have developed policies for, and have begun implementing, these programmes. In light of the WHO recommendations, and the development of routine facility-based distribution channels in malaria endemic countries, there are specific research questions and

monitoring tools that can be used to better understand the current status of these programmes.

Cross-sectional surveys are an excellent way to understand population-level experiences as a single point in time. In order to understand the extent to which ITNs are being distributed in countries with facility-based routine ITN distribution policies, nationally representative surveys could be undertaken. Specifically, surveys of women could include the questions:

1. When you attended ANC services, were you given an ITN as part of the ANC visit?

2. When your child received their childhood immunizations, were you given an ITN as part of the EPI visit?

These questions, in the context of a survey assessing the proportion of women and children attending ANC and EPI, could estimate the ITN availability, more precisely than the analysis presented in chapter 4. A nationally represented survey which included these questions could also identify regional variation in the routine facility-based distribution of ITNs within a country.

The DHS survey is a particularly valuable cross-sectional survey because of its repeated implementation and its comparability between countries and survey rounds. These surveys would be an ideal place to incorporate questions like those suggested above. The DHS currently includes two questions on the source of ITNs within the home, within the household survey malaria module. These questions were added to the most recent updates to the DHS questionnaire, the DHS7, which was first introduced in 2013. These questions are asked in reference to each ITN identified within the household and are worded as follows:

> 134(9). Did you get the net through a mass distribution campaign, during an antenatal care visit, or during an immunization visit?
>
> 1. Yes, mass distribution campaign
> 2. Yes, ANC
> 3. Yes, immunization visit
> 4. No.
>
> 135(9). Where did you get the net?

1. Government health facility
2. Private Health facility
3. Shop/Market
4. CHW
5. Religious institution
6. School
7. Other
8. Don't Know

Despite the presence of these two questions in the questionnaire, the results of Q.134(9) do not appear in any of the DHS7 recode files for any of the African countries for which a survey is currently available. The answers to Q135(9) are present in recode files, but are not interpretable without Q.134(9), due to the fact that mass distribution campaigns, and facility-based distribution, can use all (or some) of the locations listed as distribution sites. The absence of Q.134(9) from the recode means that either the question is not being asked or that the results are not being recoded into the available datasets for analysis. More importantly, it is arguable that these are not the correct questions to be asking in order to understand these distribution channels. As previous research has demonstrated, ITNs can move from the original recipient household to other households within the community; therefore the questions related to service delivery (proposed above) are more useful than the questions describing the ITNs present within a household. Questions relating to service delivery also provide valuable information to national malaria control programmes about the functionality and coverage attained through these routine health services.

If routine facility-based ITN distribution questions were integrated effectively into the DHS or other nationally-representative surveys, more detailed analyses could be conducted similar to that presented in chapter 7. Instead of grouping full countries into "have" and "have not" categories, in terms of these policies, household net ownership and use could be compared for households which did and did not receive ITNs through these distribution channels. This might be able to illustrate the effect these distribution channels have for the specific individuals directly benefitting from the distribution services.

For countries which are considering the introduction or scale-up of routine facility-based ITN distribution, longitudinal analyses, time series analyses, or cohort studies could be conducted to measure the effects of the new ITN distribution on ITN ownership and use within communities, regions, populations and nations at large. There have not been any

studies of this kind conducted on the implementation of routine facility-based ITN distribution. The benefit of study designs such as these is that ITN ownership and use could be assessed with and without these new distribution channels, which would eliminate the concern discussed in chapter 7, that countries with these programmes already have stronger malaria control programmes, in terms of consistent ITN distribution, regardless of these specific distribution channels. Studies of this nature could also incorporate process evaluations to understand the challenges and obstacles associated with implementing a new distribution channel, similar to the ones described in chapters 5 and 6, but with more robust sample sizes.

Beyond research, routine monitoring and evaluation of facility-based ITN distribution is necessary to track the progress of these services and improve implementation and service delivery. The results presented in chapters 5 and 6 highlighted the inconsistency and lack of routine monitoring and reporting systems for ITN distribution through ANC and EPI. Routine monitoring of these ITN distribution channels, through ANC and EPI, would benefit national malaria control programmes, and broader health systems, in many ways. Health workers would be able to record ITN distribution along with other ANC and EPI services delivered, allowing facility-level comparisons of routine service performance. These ITN distribution records from facilities, recorded with the numbers of women and children attending these services could be reported to the national malaria control programme, and used for the quantification of the total ITNs needed for these programmes annually. These data could be used to estimate the ITN need at each district and facility, minimizing stock-out and stock shortages in the future. Routine service delivery numbers as operational performance indicators could also be compared to survey data, currently used by national malaria control programmes, to better understand how long ITNs last in the community, and how ITNs spread within the community, after they have been distributed. At the international level, routine service delivery data could be used to create reliable estimates of ITN distribution within countries, which is currently unavailable to researchers. (As a point of comparison, WHO EPI makes coverage estimates for every vaccine in every country, publicly available through online reporting systems, and through a downloadable tablet and smart phone application.[138])

The Global Fund could help to support the development of these routine monitoring and evaluation systems by requiring accurate predictions of the total number of women

attending ANC and infants attending EPI, for whom an ITN is needed during routine facility-based ITN distribution. The Global Fund could also encourage this type of monitoring by making increased funding for facility-based ITN distribution available to those countries which can reliably estimate the programmatic need, and then report on the programme performance as a proportion of that estimated need. In the newest version of the Global Fund allocation methodology 2017-2019, health system strengthening has been identified as a funding opportunity to help countries build stronger health systems.[247] Global Fund could support countries in taking advantage of this new portion of their funding structure to enhance monitoring and evaluation of routine ITN distribution channels, as part of health system strengthening.

Researchers, international organizations, and funders, can support national malaria control programmes to make routine facility-based ITN distribution a priority. Effective implementation of these channel may alleviate pressure on campaigns, and create a consistent flow of ITNs into communities. There is evidence to support these distribution channels, but there is more that needs to be done to make them efficient and effective at providing ITNs to all pregnant women and children attending ANC and EPI.

9.5. Conclusion

The facility-based distribution of ITNs through routine ANC and EPI programmes is a valuable contribution to malaria control. The results of this project demonstrate that facility-based ITN distribution can increase ITN ownership and use in countries implementing these approaches, especially when both ANC and EPI based distribution channels are combined. ITN programmes may also benefit from the high coverage levels of ANC and EPI, and the highly equitable coverage of ITNs may support improved equity of ANC and especially EPI, when the programmes are effectively integrated.

In order for these programmes to be as effective as possible, consistent and reliable supply of ITNs is necessary at the health facilities where ANC and EPI services are provided. This not only requires reliable supply chains from the national level to the facility level in countries, but also demands a supply of ITNs, from funders at the international level, sufficient to meet the needs of the women and children attending these services.

These supply chains can be strengthened, if routine monitoring systems are put in place, providing reliable demand estimates for countries. It was clear from the results of this

project that national malaria control programmes in malaria endemic countries are working hard to provide malaria prevention interventions. Individuals at all levels of health services were making difficult decisions in resource-limited settings, in an effort to provide effective and improved health care. Better monitoring tools, functionally integrated with ANC and EPI service reporting systems, can support these national programmes to provide quality services.

At the international level, funders can commit to providing ITNs for these channels, to alleviate stock-shortages. Through the measurement of performance indicators, funders can support accurate estimates of the total women and children in need of ITNs, attending these services, and help countries to reliably measure how well that need is met.

The global malaria community has relied on surveys to measure the coverage of vector control strategies since the scale-up of mass distribution campaigns in the mid-2000s. This monitoring method has been extremely useful, but it has not been able to measure routine service delivery systems. To ensure that these routine systems reach the people who need them, and to understand where the weaknesses of this system lie, diverse monitoring tools need to be utilized. As more and different complex malaria control strategies are developed, these tools will provide useful information for the malaria control community at large.

We will not know how well implemented facility-based routine distribution of ITNs via ANC and EPI is, or how great the impact of this programme can be, until these distribution channels are seen as equally important in the fight against malaria as campaign distribution, and are given the appropriate level of attention, in terms of funding, implementation, monitoring, and evaluation. These channels are not intended to replace campaigns, but they provide a complimentary service which directly supports malaria prevention in the high risk groups of pregnant women and children under 5. The findings of this project show that these channels are providing an important service, and that there are more benefits to be gained if and when these channels are scaled-up to meet the need.

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APPENDIX A: ETHICS APPROVAL LETTERS

JOHNS HOPKINS
BLOOMBERG
SCHOOL of PUBLIC HEALTH

FWA #00000287

JHSPH Institutional Review Board Office

615 N. Wolfe Street / Suite E1100
Baltimore, Maryland 21205
Office Phone: (410) 955-3193
Toll Free: 1-888-262-3242
Fax Number: (410) 502-0584
E-mail Address: irboffice@jhsph.edu
Website: www.jhsph.edu/irb

NOT HUMAN SUBJECTS RESEARCH
DETERMINATION NOTICE

Date: May 5, 2014

To: Marc Boulay, PhD
Department of Health, Behavior & Society

Re: **Study Title**: "ANC and EPI LLIN Distribution Systems Assessment"
IRB No: 00005649

The JHSPH IRB reviewed the above-referenced new application on **May 2, 2014**. We have determined that the proposed activity described in your application involves key informant interviews about the distribution and delivery of LLINs. No personal or private information will be collected about informants.. No personal or private information will be collected. Thus, the proposed activity does not qualify as human subjects research as defined by DHHS regulations 45 CFR 46.102, and does not require IRB oversight.

You are responsible for notifying the JHSPH IRB of any future changes that might involve human subjects and require IRB oversight.

If you have any questions regarding this action, please contact the JHSPH IRB Office at (410) 955-3193 or via email at irboffice@jhsph.edu.

ES/teb

JHSPH IRB NHSR Determination_Notice_V3_07-25-12

London School of Hygiene & Tropical Medicine
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Observational / Interventions Research Ethics Committee

Katherine Theiss-Nyland
Research Degree Student
IDE / EPH
LSHTM

26 March 2014

Dear Ms.Theiss-Nyland,

Submission Title: Integrated health programming: Improving LLIN distribution

LSHTM Ethics Ref: 7326

Thank you for your letter of 21 March 2014, responding to the Observational Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

Approval is dependent on local ethical approval for the amendment having been received, where relevant.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document Type	File Name	Date	Version
Protocol / Proposal	National Level Interview guide.docx	25/02/2014	1
Protocol / Proposal	Country case study work plan_timetable.docx	25/02/2014	1
Protocol / Proposal	Fieldwork Protocol 20-03-2014-update for ethics.docx	21/03/2014	2
Information Sheet	OralConsentScript 6_ CD_March 21 2014.doc	21/03/2014	1

After ethical review

Any subsequent changes to the application must be submitted to the Committee via an Amendment form onthe ethics online applications website. The Principal Investigator is reminded that all studies are also required to notify the ethics committee of any serious adverse events which occur during the project via anAdverse Event form on the ethics online applications website. At the end of the study, please notify the committee via anEnd of Study form onthe ethics online applications website. Ethics online applications website link: http://leo.lshtm.ac.uk

Yours sincerely,

[redacted]

Professor John DH Porter
Chair

ethics@lshtm.ac.uk
http://www.lshtm.ac.uk/ethics/

Improving health worldwide

MINISTRY OF HEALTH
Malaria Control Unit

Telephone: Nairobi 2716934/5 Fax 2716935
E-Mail head.domc@domckenya.or.ke
All correspondence should be addressed to the Head, MCU
When replying please quote:

KENYATTA HOSPITAL GROUNDS
P. O. BOX 19982 – 00202
KNH NAIROBI

REF: MAL/DC/11/13/VOL.I/64

DATE: 12th May 2014

To Whom It May Concern:

Re: ANC and EPI LLIN Distribution Systems Assessment

This is to confirm that Katherine Theiss-Nyland and Yves Cyaka, employed by NetWorks Project funded by USAID, the London School of Hygiene and Tropical Medicine and Tropical Health, are conducting an evaluation of routine continuous distribution of LLINs through ANC and EPI services on behalf of the Malaria Control Programme.

The results of this evaluation will be shared with the government and partner stake-holders within the country. They will also be used to inform further analysis and frameworks highlighting a broader understanding of programme implementation across countries.

Kindly accord them the necessary assistance.

Thank you.

[redacted]

Dr. Waqo Ejersa [redacted]
Head – Malaria Control Unit

Telegrams: MINMED, Lilongwe Med.....

Telephone: 01 752 450

Fax: 01 759 963

Reply please quote Ref

Ministry of Health

P.O. Box 30377,

Lilongwe 3,

MALAWI

Communications should be addressed to:

Secretary for Health

29th April, 2014

REF: MAL/CHSU/6/VOL.291

Katherine Theiss-Nyland and Yves Cyaka
NetWorks
Johns Hopkins University Bloomberg School of Public Health Center for Communication Programs
London School of Hygiene and Tropical Medicine
Tropical Health

To: Whom It May Concern:

Re: ANTENATAL CLINIC AND EXPANDED PROGRAMME ON IMMUNIZATION LONG LASTING INSECTICIDES DISTRIBUTION SYSTEMS ASSESSMENT

This letter is to confirm that the above named, Katherine Theiss-Nyland and Yves Cyaka, employed by NetWorks Project funded by USAID, are conducting an evaluation of routine continuous distribution of Long Lasting Insecticide Treated Nets (LLINs) through Antenatal Clinic (ANC) and Expanded Programme on Immunization (EPI) services with the support of the National Malaria Control Programme.

It is understood that the evaluation will be conducted in the form of a rapid assessment including interviews with national, district, and health facility staff involved in the relevant health services for LLIN delivery, including ANC, EPI and Malaria Control. The results of this evaluation will be shared with the government and partner stake-holders within country, as well as used to inform further analysis and frameworks highlighting a broader understanding of programme implementation across countries.

Yours sincerely,

[redacted]

Doreen Ali

DEPUTY DIRECTOR OF PREVENTIVE HEALTH SERVICES (Malaria)

MINISTERE DE LA SANTE ET DE L'HYGIENE PUBLIQUE

PROGRAMME NATIONAL
DE LUTTE CONTRE LE PALUDISME

Tél : 20-22-32-56 ; **Fax** : 20-22-32-56

N° 000216 /MSHP/PNLP

REPUBLIQUE DU MALI
UN PEUPLE - UN BUT- UNE FOI

Pour: Katherine Theiss-Nyland et Yves Cyaka
NetWorks
Johns Hopkins University Bloomberg School of Public Health Center for Communication Programs
London School of Hygiene and Tropical Medicine
Tropical Health

À qui de droit:

Re: ANC et EPI MILD évaluation des systèmes de distribution

Cette lettre est de confirmer que les nommés, Katherine Theiss-Nyland et Yves Cyaka, employés par le projet Network financés par USAID, la London School of Hygiene et Tropical Medicine, effectuent une évaluation sur la distribution de routine des MILDA a travers la CPN et les services du PEV en collaboration avec le Programme National de lutte contre le paludisme au Mali.

Il est entendu que l'évaluation sera réalisée sous la forme d'une évaluation rapide, y compris des interviews avec le personnel du niveau national, régional, et périphériques impliqués dans la distribution des MILD à travers les services CPN et PEV. Les résultats de cette évaluation seront partagés avec les parties prenantes du ministère et des partenaires au sein du pays, ainsi que celui utiliser pour informer une analyse plus approfondie en accentuant une compréhension plus large de la mise en œuvre des programmes dans le pays.

Cordialement,

Bamako, le 04 AVR 2014
P/Le Directeur P.I
[redacted] joint

Dr Mohamed Keïta
[redacted]

RWANDA BIOMEDICAL CENTER

A Healthy People. A Wealthy Nation

Kigali on, 25th March 2014

Malaria and other Parasitic Diseases Division

To Whom It May Concern

Re: Rwanda ANC and EPI LLIN Distribution Systems Assessment

This letter is to confirm that the above named, Katherine Theiss-Nyland and Yves Cyaka, employed by NetWorks Project funded by USAID, the London School of Hygiene and Tropical Medicine and Tropical Health, are conducting the programme evaluation of routine continuous distribution of LLINs through ANC and EPI services in collaboration with the Malaria & Other parasitic diseases Division RBC.

This evaluation will be conducted in the form of a rapid assessment including interviews with national, district, and health center staff involved in the relevant health services for LLIN delivery, including ANC and EPI. The results of this evaluation will be shared with the Malaria & other parasitic diseases Division and partner stake-holders within country, as well as used to inform further analysis and frameworks highlighting a broader understanding of the LLINs delivery programme implementation.

The team will be accompanied with a staff of the Malaria & other parasitic diseases Division RBC.

I would kindly request you to facilitate the evaluation team to get all in formations required to achieve their mission.

Please do not hesitate to contact Ms Yvette Muyirukazi, the ITN specialist in the Malaria & other parasitic diseases Division RBC.

Thank you for your collaboration.

HEAD OF MALARIA & OTHER
[redacted]ITIC DISEASES DIVISION
BIOMEDICAL CENTER

Dr. Corine KAREMA
Head of Malaria and other Parasitic Diseases Division

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Observational / Interventions Research Ethics Committee

Ms. Katherine Theiss-Nyland
LSHTM

12 August 2016

Dear Katherine

Study Title: DHS Analysis - Mosquito net use in Africa

LSHTM Ethics Ref: 10391

Thank you for responding to the Observational Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

Approval is dependent on local ethical approval having been received, where relevant.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document Type	File Name	Date	Version
Investigator CV	K Theiss-Nyland_CV_2016	03/08/2016	1
Covering Letter	cover letter ethics	11/08/2016	1
Protocol / Proposal	DHS Protocol for Ethics	11/08/2016	1

After ethical review

The Chief Investigator (CI) or delegate is responsible for informing the ethics committee of any subsequent changes to the application. These must be submitted to the Committee for review using an Amendment form. Amendments must not be initiated before receipt of written favourable opinion from the committee.

The CI or delegate is also required to notify the ethics committee of any protocol violations and/or Suspected Unexpected Serious Adverse Reactions (SUSARs) which occur during the project by submitting a Serious Adverse Event form.

At the end of the study, the CI or delegate must notify the committee using an End of Study form.

All aforementioned forms are available on the ethics online applications website and can only be submitted to the committee via the website at: http://leo.lshtm.ac.uk

Additional information is available at: www.lshtm.ac.uk/ethics

Yours sincerely,

[redacted]

Professor John DH Porter
Chair

ethics@lshtm.ac.uk
http://www.lshtm.ac.uk/ethics/

APPENDIX B: EXAMPLE INTERVIEW GUIDE FOR QUALITATIVE STUDY IN FOUR COUNTRIES

Facility Level Interview for NMCP, EPI and ANC

Ministry of Health, WHO, UNICEF, NetWorks, Deliver, and any other relevant partner organization

Title:

(circle all that apply)

Do you work on:	EPI	ANC	Malaria/LLINs
Level of work:	National	Regional	Facility
Organization:	MOH	Partner: _____	

General roles and responsibilities in your job:

Policy and Management:

POLICIES AND GUIDELINES

- Do you use any policies or guidelines for your work each day? (EPI schedule, ANC services, integrated services, broad LLIN delivery, etc)
- Are there SOPs in place for service delivery?
- Are there guidelines, job aides, or SOPs for your work that specifically mention integrated services and/or continuous LLIN distribution?

PROGRAMME MANAGEMENT

- Who is responsible for programme management and implementation at this facility? Who oversees the delivery of this programme?
- Are any persons specifically responsible for integration?

- How is success defined and measured for the programme?
- Is coverage used as a measure, and how is it defined?

What policy and management factors, if any, contribute to the success of this programme? (General programme success and specific integration success)

What policy and management factors, if any, hinder the success of this programme? (General programme success and specific integration success)

Programme Implementation and Human Resources:

PROGRAMME

- Can you explain how service delivery works?
- At which point in ANC and EPI are nets distributed? Are there other ways that nets are distributed?
- Who is responsible for providing each service?
- Is there a cost associated with any of the services provided?
- Do any incentives exist for performance?
- Is there enough time to complete all the tasks during ANC and EPI visits?
- Is there a difference between LLINs for ANC, EPI and campaigns?
- Are there times when someone does not get an LLIN who should receive one? Can you explain how that happens?
- Are there times when someone receives an LLIN who is not technically eligible? Can you explain how that happens?

HUMAN RESOURCES

- What kind of training, if any, did you receive for each programme or service that you provide? (stock management, service delivery, reporting, quantification, etc)
- Is there on-site supervision for any of the programme?

What programme delivery and/or human resource factors, if any, contribute to the success of this programme?

What programme delivery and/or human resource factors, if any, hinder the success of this programme?

Logistics:

SUPPLY QUANTIFICATION AND STOCK MANAGEMENT

- What are all the commodities and supplies associated with your programme?
- How is supply quantification and expected need calculated?
- Who reports on stock levels at this facility? Where do reports go?
- How are more supplies ordered and delivered to this facility?
- What kind of stock-management system is in place?
- How often are new shipments of supplies received at this facility?
- Is there any separation of supplies for campaigns compared to those for routine health service distribution? (primarily for LLINs, but also for vaccine supply management)

SUPPLY DISTRIBUTION

- Where do the supplies come from for this facility?
- Do all health supplies come from the same place?

What logistics system factors, if any, contribute to the success of this programme?

What logistics system factors, if any, hinder the success of this programme?

Data Collection, Management and Use:

PROGRAMME DATA

- What data are recorded at the facility level during service delivery?
- How are those data collated?
- Where do data reports go?
- How is service delivery data used at this facility? (Do you aggregate the data? Do you measure against targets?)

- What kind of feedback do you receive based on reports?
- Do you monitor the programme here at the facility? Do you use coverage data for programme monitoring? How is it measured?

LOGISTICS DATA

- What data are collected and kept for stock management?
- How are stock-management data used?
- What kind of stock-level data and reports are completed here?
- What kind of feedback exists for stock management?
- What tools (if any) exist for quantification of stock needs?

What data collection, management and use factors, if any, contribute to the success of this programme?

What data collection, management and use factors, if any, hinder the success of this programme?

APPENDIX C: ORAL CONSENT SCRIPT AND FORM (ENGLISH)

PURPOSE

You are invited to take part in a programme evaluation. The purpose of this programme evaluation is to conduct rapid assessments of the continuous distribution systems for Long lasting insecticide treated nets (LLINs) within ANC and EPI services in 4 African nations (Malawi, Rwanda, Nigeria, and Mali). These assessments will provide information on the best practices, barriers, and limitations to routine continuous distribution of LLINs. For each country, the assessment will produce recommendations to strengthen service delivery, with country-specific approaches.

Some information from the assessments may be used in further research to look for general themes towards successful implementation. This information may also be used towards the development of tool to support decision making for LLIN distribution scheduling.

You have been invited to participate in this programme evaluation due to your role in one or more child health programmes or health commodity logistics systems.

PROCEDURES

If you do participate, I will ask you a set of questions related to the continuous distribution system for LLINs, EPI and/or ANC. The questions will relate to your roles and responsibilities, your understanding of how the programme is run, and your ideas on the strengths and weaknesses of the system. In total our conversation will last between 30 minutes and 1.5 hours. Your participation is entirely voluntary. If you choose to participate, you can change your mind and opt out at any time.

RISKS/DISCOMFORTS

We will not ask you any questions of a personal nature, but we still want to ensure that your confidentiality is protected. As this evaluation relates to your roles and responsibilities in your work-place, we will make every effort to protect your identity for thoughts and observations you want to remain anonymous. Any reports and publications from this research will not include individual names, roles or titles, to ensure anonymity,

unless you especially give consent otherwise. Results will be reported in aggregate, looking at themes and trends, so no individual will be identified for any specific comment.

BENEFITS

The goal of this study is to improve the delivery and integration of health services though EPI and ANC, specifically LLIN distribution. There is no immediate benefit to you from participating in this study. The results of the programme evaluation may result in more efficient health systems, which would streamline and improve service delivery leading to improved work-place protocols and procedures. This research intends to improve health service integration and delivery of LLINs for the prevention of malaria. If the research is successful community members will benefit from more efficient health services delivery and decreases in malaria incidence.

VOLUNTARY PARTICIPATION

You do not have to agree to be in this study, and you may change your mind at any time.

- Call the principal investigator, Marc Boulay, at , +1-410-659-6300 if you have questions or complaints about being in this study.
- If you have any questions about your rights as a research participant, or if you think you have not been treated fairly, you may call the Johns Hopkins School of Public Health Institutional Review Board (IRB) at 410-955-3193, or 1-888-262-3242.

PERMISSION TO PROCEED

Do you have any questions about the information that I have given you?

Are you okay to proceed?

If you are happy to proceed with this interview can you please sign the statement below and choose the level of anonymity you would like to maintain for any further use fo this information.

Statement of the Participant:

I have read and/or heard the information about this project and have been given the opportunity to ask questions. Any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate in this programme evaluation.

Yes	No	
□	□	Use my job title/position, organization and level of service delivery
□	□	Use of general themes and ideas linked to level of service delivery
□	□	Use of anonymous quotes linked to level of service delivery

Print Name of Participant_____

Signature of Participant _____

Date _____
Day/month/year

Statement by the researcher/person taking consent:

I have provided accurate information about this research to the participant. I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Print Name of Researcher/person taking the consent

_____

Signature of Researcher /person taking the consent

_____

Date _____
Day/month/year

APPENDIX D: MATHEMATICAL EQUATIONS OF CONCENTRATION INDICES FOR BINARY VARIABLES

$$C(h) = \int^{C}(\mu_h, n)\sum_{i=1}^{n} z_i\, h_i = \frac{2}{n^2\mu_h}\sum_{i=1}^{n} z_i\, h_i$$

- $z_i = (n+1)/2 - \lambda_i, f(\mu_h, n) > 0$
- n is the number of individuals in the population
- λ_i represents the socio-economic rank of the individual, with the poorest equal to 0 and the richest equal to 1.
- μ_h represents the coverage of the population
- h represents whether or not the individual has the health resource. In a situation where the health resource is binary (either present or absent), h is either 0 or 1 for each individual. The result is a vector $h = (h_1, h_2, h_3 \ldots h_n)$ which represents the distribution in the population as a whole.

The Wagstaff index for health: W(h), and the Erreygers index for health: E(h), are modified versions pf the standard C(h), presented below:

$$W(h) = \int^{W}(\mu_h, n)\sum_{i=1}^{n} z_i\, h_i = \frac{2}{n^2(1-\mu_h)\mu_h}\sum_{i=1}^{n} z_i\, h_i$$

$$E(h) = \int^{E}(\mu_h, n)\sum_{i=1}^{n} z_i\, h_i = \frac{8}{n^2}\sum_{i=1}^{n} z_i\, h_i$$

APPENDIX E: DESCRIPTION OF THREE IMPORTANT PROPERTIES OF CONCENTRATION INDICES

The below three properties are identified by health economists as important features of any concentration index. These three properties are met by both the Wagstaff: W(h), and Erreygers: E(h), corrected concentration indices for health, and are maintained when applying these indices to binary and bounded variables.

1. The transfer property

The transfer property is a cornerstone of concentration index theory, and says that a transfer of health from a richer individual to a poorer individual will result in a corresponding shift towards a more pro-poor concentration index measure, and vice versa.[186]

2. The mirror property

This property states that measures of inequality in health *(h)* or ill-health *(1 – h)* should be compliments of each other, with opposite signs, creating mirror images in measurements.[186,187] For unbounded variables, such as height or wealth, there is no way to measure the mirror. For bounded health measures, however, comparable alternatives of health and ill-health measurements are often used: survival vs mortality, proportion vaccinated vs proportion unvaccinated, etc. When the mirror property is not satisfied, the calculation of a concentration index score could result in a pro-poor inequity in both health and the comparable ill-health measure, (survival and mortality, for example), which is counter-intuitive.[187] Both E(h) and W(h) ensure that the measurement of health or ill-health results in an equal and opposite value.[186,187,192] The mirror property is especially important if we are comparing different health programmes which may have standard measures which differ from one another. A concentration index that meets the mirror property allows the comparison of equity in mortality (an ill-health measure) vs equity in vaccination coverage (a health measure), for example.[186] (It is important to note that C(h) does not satisfy this property, making it a less useful tool for measuring inequity in bounded health variables.)

3. The cardinal invariance property

The cardinal invariance property states that a linear transfer of the health variable used will not affect the resulting value produced as the score of the concentration index. In other words, the scale used for the health measure will not change the equity estimate.[186] W(h) and E(h) both satisfy the principle of cardinal invariance. For example, the W(h) or E(h) equity measure for fever would be the same whether measured in Fahrenheit or Celsius.[186]

APPENDIX F: EXCERPT FROM GLOBAL FUND INDICATOR GUIDANCE SHEET ON THE REPORTING OF ITN DISTRIBUTION THROUGH ANC AND EPI

Indicator code (A)	Indicators (B)	Numerator (C)	Denominator (D)	Data type (E)	Target/Result Aggregation (F)	Disaggregation of reported results (G)	Geographic coverage (H)	Data source (I)	Additional information (J)
VC-3	Number of long-lasting insecticidal nets distributed to-targeted risk groups through continuous distribution	Number of insecticide-treated nets distributed to targeted risk groups through continuous distribution (ANC, EPI etc.)	Not applicable	N	Non-cumulative	Pregnant women; Children <5; Migrant workers/ refugees/IDPs; Others (specify)	National Sub-national (specify)	Program records of ITN distribution at specific sites	When setting targets, specify: 1) Service delivery point- e.g. ANC, EPI, etc. 2) Targeted risk groups

ITNs distributed through ANC and EPI (or other continuous distribution channels such as schools) are reported as a single number (C), without a denominator (D), based on a target set. Though the guidelines require countries to specify which programme is being used, and which risk group is being targeted (J), countries are not asked to provide information on the total number of person in that target group eligible to receive the service.

* Letters have been added to support explanation

APPENDIX G: EXCERPT FROM GLOBAL FUND INDICATOR GUIDANCE SHEET ON THE REPORTING OF ITN OWNERSHIP AND USE

Indicator code (A)	Indicators (B)	Numerator (C)	Denominator (D)	Data type (E)	Target/Result Aggregation (F)	Disaggregation of reported results (G)	Geographic coverage (H)	Data source (I)	Additional information (J)
O-1a	Proportion of population that slept under an insecticide-treated net the previous night	Number of individuals who slept under an ITN the previous night	Total number of individuals who spent the previous night in surveyed households	%	Not applicable	Sex (male, female)	National Sub-national (specify)	Household surveys such as periodic malaria indicator survey, DHS or MICS	Wealth quintile Rural/Urban
O-6	Proportion of households with at least one insecticide-treated net for every two people	Number of households with at least one ITN for every two people	Number of households surveyed	%	No applicable	None	National Sub-national (specify)	Household surveys such as periodic malaria indicator survey, DHS or MICS	

Unlike the indicator for ITN distribution through ANC and EPI, seen in Appendix F, the indicator guide for ITN net ownership and use requires a denominator (D) and is reported as a percentage of the total target population (E).

*The same format of numerator and denominator, presented as a percentage is used for the indicators: “Proportion of children under five years old who slept under an insecticide-treated net the previous night”, “Proportion of pregnant women who slept under an insecticide-treated net the previous night”, and “Proportion of households with at least one insecticide-treated net”